Descriptions of New Carboniferous FOSSILS from the Western States.

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ECHINODERMATA.

Genus POTERIOCRINITES, Miller.

The typical forms of this genus have a more or less obconical body, with a protuberant base, strong rounded column, and generally long, stout, bifurcating arms, always composed each of a single series of pieces. The body is composed of five basal pieces, alternating with five subradials, and five first radials, all alternating with the latter, excepting one on the anal side, which rests directly upon the upper truncated edge of one of the subradials.

The anal series consists, normally, of two alternating vertical ranges of pieces, the lowest piece of which rests between the upper sloping sides of two of the subradials, partly under one side of the first radial on the right, and connects above its middle, on the left, with another resting on the upper truncated edge of one of the subradials, and joining the first radial on the left, while usually one or two more above these connect with others belonging more properly to the base of the so-called proboscis. The primary radials above the first are free, and generally smaller, and vary in number in the different rays of the same individual, from about two to eight, ten, twelve or more, below the first bifurcation. The ventral part of the body is produced upward in the form of a cylindrical, or more or less expanded proboscis (so called), generally as wide as the whole space between the arms below, and composed of regular hexagonal pieces, often with pores passing through the sutures between. The opening is said to be near the top of the proboscis, though we have never seen it in any of the numerous specimens we have examined.

In addition to the species agreeing in all respects with the characters above given, there are numerous others which, although conforming in general structure with the typical forms, still depart so widely in some of their characters, that when the extremes are compared, it seems difficult to believe that they can all belong to one genus. And yet they are all linked together by so many intermediate gradations that, in the present state of our knowledge of these fossils, we are at a loss to see how they can be separated more than subgenerically. For some of these types the names *Scaphiocrinus*, *Zeacrinus*, *Cœliocrinus*, etc., have been proposed, either as subgenera or as distinct genera from *Poteriocrinites*. Adopting the former view, these groups may, in order to facilitate their study, be arranged as follows, commencing with *Poteriocrinites* proper:

1.—Genus POTERIOCRINITES, Miller.

Represented by such forms as *P. crassus*, Miller, *P. conicus*, Phillips, *P. Missouriensis*, Shumard, and *P. Swallovi*, M. and W.

2.—Subgenus SCAPHIOCRINUS, Hall; or GRAPHIOCRINUS, de Koninck and Le Hon.*

The characters distinguishing this group, as it is generally understood, from *Poteriocrinites* proper, may be stated as follows: Species generally of smaller size and less robust habit, with only two (or rarely three) primary radial pieces

* It seems highly probable, as has been suggested by Mr. Lyon and Dr. Shumard, that the type on which de Koninck and Le Hon founded their name *Graphiocrinus*, may have five minute basal pieces hidden by the column in the concavity of the under side, within the range apparently belonging to the basal series, as is the case with many American forms. If so, the typical form of *Scaphiocrinus* would present no difference of even subgeneric importance, and the name *Scaphiocrinus* would have to be abandoned; in which case the American species would have to be called *Graphiocrinus simplex*, *G. spinobrachiatus*, *G. tortuosus*, &c.

to each ray, excepting sometimes in the anterior ray. Second radial pieces generally contracted in the middle, and usually separated from the first radials by gaping sutures. Arms generally shorter and sometimes simple, often with the pieces so arranged as to present a zigzag appearance. Body short and rounded or concave below, or varying to an inverse bell shape or obconic outline.* Anal pieces sometimes with only a single one included as a part of the wall of the body.

Includes *S. simplex* (the type), *S, spinobrachiatus, S. tortuosus, S. doris, S. æqualis, S. carinatus, S. dichotomus, S. dactyliformis, S. divaricatus, S. Halli, S. nodobrachiatus, S. lyriope, S. orbicularis, S. ramosus, S. robustus, S. subcarinatus, S. subtortuosus, S. uncus*, and *S. Whitei*, Hall, as well as his *Cyathocrinus macropleurus*. Also *S. longidactylus*, McChesney and *S. decadactylus, S. macrodactylus, S. solidus, S. Wachsmuthi, S. Clio, S. Thetys, S. nanus, S. delicatus, S. penicillus, S. fiscellus, S. scalaris, S. juvenis, S. rudis, S. liliiformis*,† and *S. notabilis*, M. and W.

Poteriocrinites dactyloides, P. latifrons, of Austin, and *P. tenuis*, of Miller, would also fall into this section, giving it the limits usually admitted.

3.—Subgenus ZEACRINUS, Troost.

Differs from *Scaphiocrinus* in having the body more generally rounded and concave below, and *always* with more than one anal piece included as a part of the walls of the body. Also in having the arms generally more frequently bifurcating and the inner divisions all simple, as well as in having the free radials generally wider.

Includes *Z. magnoliaformis*, Troost; *Z. elegans, Z. ramosus, Z. paternus, Z. intermedius, Z. scoparius*, and *Z. Wortheni*, Hall; *Z. bifurcatus*, McChesney; *Z. ovalis*, Lyon and Cassiday; *Z. spinosus*, Owen and Shumard; and *Z. discus, Z. Troostanus, Z. scobina, Z. asper*, and *Z. lyra*, M. and W. Also *Z. perangulatus* and *Z. sacculus*, White.

4.—Subgenus CŒLIOCRINUS, White.

Differs from *Scaphiocrinus* in having the ventral prolongation much inflated or balloon shaped, instead of nearly cylindrical.

Includes *Poteriocrinus dilatatus*, and *P. ventricosus*, Hall.

POTERIOCRINITES? PERPLEXUS, M. and W.

Body small, somewhat cup shaped, with sides a little expanding above and rounding to the column below; height to top of first radial pieces more than half the breadth at the same point. Base small, much depressed, or nearly flat, with a pentagonal outline. Subradial pieces each nearly as large as the whole base, about as wide as long, three hexagonal and two heptagonal (counting a very obtuse angle at the middle of the base of each). First radials nearly twice as large as the subradial pieces, and proportionally wider, pentagonal in form, and each with a moderately deep rounded sinus, rather more than half the breadth of its upper margin, for the reception of the suc-

* It is worthy of note that the original typical species of *Scaphiocrinus* (*S. simplex*, Hall), has its body much depressed and rounded, but not concave, below, with but one anal piece only, included as part of the walls of the body. It also has but two radials to each ray, with all the arms simple, and two from each ray, excepting in the anterior ray, which supports only one arm. [This species is wrongly described, and illustrated by the cut, in the text of the Iowa Report, part ii, vol. 1, p. 550—52, as having the arms double from their origin on the second radials all around, there being but one arm in the anterior ray in the type specimen now before us.] The group, however, has been extended by Prof. Hall and others, so as to include species presenting all the characters given above, and might be divided into several sections distinguished from each other and from the typical form, on quite as good characters as those distinguishing the latter from *Zeacrinus*.

† This is our *Poteriocrinus carinatus*, (Illinois Report, vol. iii, pl. 17, fig. 1). As Prof. Hall had previously used the name *carinatus* for a *Scaphiocrinus*, it becomes necessary to give our species a new name. At the time we referred it to *Poteriocrinites* proper we were not aware that there is a little group of species having the other characters of *Scaphiocrinus*, and yet with three radial pieces to each ray.

ceeding radials. Anal pieces presenting the usual arrangement of a double alternating series, the lowest being partly under one side of the first radial on the right, while the next on the left of this rests on the truncated upper edge of one of the subradials, and these connect with others above, that form the base of the proboscidiform ventral extension. Second radials very small and short, or scarcely more than filling the sinuses in the first. Third radials nearly as wide as long, quadrangular and only about half as wide as the first radials. Fourth radials a little larger than the third, pentagonal in form, and supporting the arms on their superior sloping sides.

Arms slender, rounded and proportionally long, bifurcating first above the last radial, generally on the third or fourth piece, above which each of the subdivisions bifurcates again several times. Arm pieces generally about as wide as long, and not wedge shaped.

Proboscidiform extension at least half (and perhaps more than half) as long as the arms, entirely lateral, and not more than half as wide as the body, below; apparently somewhat thicker above. Body plates not convex, but merely granular, and joined by close fitting sutures. Column slender, round, and composed of nearly equal moderately thick pieces, near the base.

Height to top of first radial pieces, about 0·15 inch; breadth, 0·24 inch; length of arms, about 0·95 inch.

This is one of those few intermediate types such as we occasionally meet with in various departments of Natural History, when extensive collections can be studied, connecting or standing, as it were, intermediate between two genera. That is to say, it combines some of the characters usually regarded as belonging especially to *Poteriocrinites* with others equally characteristic of *Cyathocrinites*. Its body has much the usual form of *Cyathocrinites*, with the double alternating series of anal pieces precisely as we see in *Poteriocrinites*. On the other hand, it has the narrow, decidedly lateral proboscidiform ventral extension of *Cyathocrinites*, and might, with almost equal propriety, as far as we yet know, be called *Cyathocrinites? perplexus*. The existence of such a type would, in the estimation of some naturalists, be regarded as a sufficient reason for uniting the genera *Poteriocrinites* and *Cyathocrinites*. In this opinion, however, we cannot concur, for we believe that if all the genera thus connected by a few obscure forms were united, it would be found impossible to fix any limits whatever to such groups, with all the extinct types before us. Possibly characters may be found, however, warranting the establishment of a new genus for such forms.

Specifically this little Crinoid seems to be most nearly allied to our *Cyathocrinus? enormis*, but it differs in the number and arrangement of its anal pieces, as well as in having its arm pieces scarcely one-half as long in proportion to thickness.

Locality and position.—Lower part Burlington group of the Lower Carboniferous, Burlington, Iowa. No. 264 of Mr. Wachsmuth's collection.

Subgenus SCAPHIOCRINUS, or GRAPHIOCRINUS.

SCAPHIOCRINUS RUDIS, M. and W.*

Body much depressed, about four times as wide as high, flat or a little concave below, the flattened part including the basal, subradial, and about half the length of the first radial pieces. Base very small, a little impressed, and entirely hidden by the column. Subradial pieces of moderate size, extendieg out horizontally from the column; the one on the anal side, however, curving up distinctly, and the others slightly, at the ends; all flat, excepting the curvature mentioned, and pentagonal in outline (the superior angle being rather salient), excepting the one on the anal side, which is hexagonal, being trun-

* Although we write the names *Scaphiocrinus* and *Zeacrinus* in this paper for the sake of brevity, as if they were regarded as distinct genera, we really use them as subgeneric names under *Poteriocrinites*, as already explained.

cated above for the reception of the anal piece. First radial pieces three or four times as large as the subradials, twice as wide as long, very tumid in the middle, and pentagonal in form, the lateral margins being longer than the inferior, and the superior one straight, and equaling the entire breadth. Second radial pieces of about the same size as the first, which they equal in breadth below, though they are a little longer, and proportionally narrower above, and have each a strong angle down the middle of the outer side; all pentagonal in outline (excepting the anterior one, which is quadrangular), the superior angle being salient; each supporting two arms on the superior sloping sides, excepting the anterior one, which bears but a single arm.

Of anal pieces one only is included as a part of the walls of the body, and this one rests upon the upper truncated edge of the largest, curved subradial, and connects on each side with a first radial. Succeeding anals unknown.

Arms moderately strong, simple, angular on the dorsal side, and composed of short wedge shape pieces, alternately projecting out laterally on each side, in the form of spine-like processes. Column small, round, and composed near the base of pieces of moderate thickness, with each a projecting ridge around its middle, and perforated by a minute round canal. Sutures between the first and second radial pieces widely gaping when the arms are folded up vertically.

Height of body, 0·08 inch to the top of first radials; breadth, 0 33 inch; length of remaining portions of arms, about 0·85 inch; thickness of column at base, 0·17 inch.

This belongs to the typical section of *Scaphiocrinus*, as it has but a single anal piece included as a part of the body, and all its arms are simple. Specifically it appears to be most nearly allied to *S. spinobrachiatus*, Hall (Bost. Jour. Nat. Hist. vol. vii, p. 306), but differs in having its body much depressed, more flattened below, and its base is so mueh smaller as to be entirely hidden by the column, instead of projecting out around it. Its subradial pieces also differ in not being more elevated than the others, nor impressed at the angles. The arms in the specimen from which our description was drawn up, are not quite complete at their ends, though from a slight tapering and appearance of a tendency to curve together toward their extremities, it seems to be quite probable that they were not more than an inch in length, while those of the species *spinobrachiatus* are said to be about three inches in length, in the original specimen, and still imperfect at the ends.

Locality and position. Upper division of the Burlington group, Burlington, Iowa. Lower Carboniferous. No. 275 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS MACRODACTYLUS, M. and W.

Body obconical, or tapering rather gradually from the top of the first radials to the column. Base about twice as wide at the top as long, truncated below, the breadth of the column; basal pieces a little longer than wide, pentagonal in form, with the lateral margins longer than the upper sloping sides. Subradial pieces once and a half to twice the size of the basals, hexagonal in form, excepting one (or possibly two) on the anal side, which is larger than the others and heptagonal, being truncated above for the reception of an anal piece. First radial pieces wider and a little shorter than the subradials, and all wider than long. Second radials distinctly longer than wide, rounded and constricted in the middle, with a pentagonal outline (excepting the one in the anterior ray, which is truncated above), and supporting the arms on their superior sloping sides. Arms nine or ten, simple from their origin, very long, slender, rounded and composed of wedge form pieces, which have their longer side about twice the length of the shorter and equaling their breadth, but not projecting so as to give the arms a zigzag appearance. Pinnulæ long, moderately stout, and composed of joints about twice as long as wide. Anal pieces unknown.

Surface finely granular. Column round, moderately stout and composed of rather thin pieces, of uniform size near the base, with a rather small, round or subpentagonal central canal.

Length of body below the summit of the first radial pieces, 0·40 inch, breadth about 0·50 inch. Diameter of column at base, 0·18 inch. Entire length of arms unknown, as they are all broken at the extremity, with the remaining portion measuring 3·40 inches in length, with thickness of about 0·10 inch throughout.

This species has the long straight arms, obconic body, protuberant base, and general physiognomy of the typical forms of *Poteriocrinites*, but differs in having but two primary radial pieces to each ray, with the sutures between them somewhat gaping, as in *Scaphiocrinus*. Specifically it is not closely allied to any of the other known species. In the form of its body it is most nearly allied to our *Pot. subimpressus*, which Mr. Wachsmuth has ascertained probably has only two primary radial pieces to each ray, and hence seems to fall into *Scaphiocrinus*, giving that group the wide limits usually admitted. The species here under consideration, however, will be readily distinguished from the *Pot.* (*Scaph.*) *subimpressus*, by not having its body plates impressed at the corners, and all distinctly thinner, as well as by its less robust general habit.

Locality and position. Lower beds of the Burlington group, Burlington, Iowa. Lower Carboniferous. No. 277 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS NANUS, M. and W.

Body very small, expanding rapidly from the column to the top of the first radials, where it is about once and a half as wide as high. Base small, slightly projecting, pentagonal in outline, and nearly covered by the round, flat facet for the attachment of the column. Basal pieces showing a very short, minute pentagonal facet above the column. Subradial pieces a little wider than long, three with a pentagonal outline, and two on the anal side hexagonal, there being no well defined angle visible at the middle of the under side of any of them. First radials of about the size of the subradial pieces, a little wider than long, pentagonal in form, and somewhat rounded on their outer sides, in consequence of the sutures between them being impressed. Second radials longer than wide, or nearly twice as long as the first, all pentagonal in outline and rounded and more or less constricted in the middle, each supporting two arms on its upper sloping side.

Anal pieces consisting of a double alternating series, the lowest one of which rests between the upper sloping sides of two of the subradials, and supports one side of the first radial on the right, while on its left it connects, above the middle, with another anal resting upon the truncated upper side of one of the subradials, and connecting on its left with the first radial on that side; above these three or four other pieces are seen between the arms extending up and joining with the base of the so-called proboscis.

Arms somewhat rounded on the dorsal side, each bifurcating on the sixth or seventh piece above the second primary radials, and composed of wedge form pieces that are a little longer than wide on the longer side. Above the bifurcations these pieces are somewhat constricted and each one projecting laterally above, on its longer side, for the reception of the pinnulæ, so as to present a rather zigzag appearance. Pinnulæ moderately stout, and rather distantly separated from each other; composed of joints a little more than twice as long as wide.

Surface of body plates even, and finely granular.

Height of body, 0·10 inch to top of first radial pieces, where it measures about 0·20 inch in breadth. Arms about 0·75 inch in length.

In size and general appearanee this species is quite similar to *S. dichotomus*, of Hall, with which it also agrees in having its arms bifurcating but once above their origin on the second radials. It differs, however, in having its second radial pieces rounded instead of angular, and distinctly longer in proportion to

breadth, as is also the case with all the arm joints. It also differs in having two arms to each ray, all around, instead of only one in the anterior ray, as well as in the number of pieces in each arm below the bifurcations. Its arms are likewise proportionally more slender.

Locality and position. Lower division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. Mr. Wachsmuth's collection.

SCAPHIOCRINUS STRIATUS, M. and W.

Body below the top of the first radial pieces subhemispherical, being regularly rounded below; composed of thick plates, which are ornamented with distinct, somewhat broken striæ, running vertically, so as to radiate from the base, but all parallel with each other on each individual plate. Basal pieces hidden by the column externally. Subradials about as wide as long, five of them showing a pentagonal outline (there being no visible angle at the middle of their bases on the outside), and one on the anal side hexagonal, the latter being a little larger than the others. First radial pieces slightly shorter than the subradials, but about once and a half as wide, all having a general pentagonal form, being broadly truncated their entire breadth above, and having the articulating surfaces each marked with two very distinct transverse furrows. First anal piece a little longer than wide, hexagonal in form, and resting upon the truncated upper end of the odd subradial between two of the first radials, beyond which it projects nearly half its length; truncated above for the reception of a second anal. Other parts unknown.

Sutures distinctly channelled, so as to impart a moderate convexity to the plates.

Height to top of first radials, 0·20 inch; breadth, 0·46 inch.

This is a typical *Scaphiocrinus*, as far as its parts are known, and seems to be most nearly related to *S. simplex*, of Hall, from which it may be at once distinguished, however, by its channelled sutures, convex plates and peculiar sculpturing.

Locality and position. Lower Burlington beds, of the Lower Carboniferous, at Burlington, Iowa. No. 274 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS PENICILLUS, M. and W.

Body small, somewhat basin shaped, or about three times as wide as the height to the top of the first radial pieces, truncated and a little concave below. Base very small, and nearly or quite hidden by ths column in the shallow concavity of the under side. Subradials generally wider than long, with a pentagonal outline, excepting one on the anal side, which has the upper angle a little truncated, so as to make a sixth angle; there is doubtless also another obtuse angle at the middle of the lower side of each, covered by the column. First radial pieces wider than high and pentagonal in form. Second radial pieces nearly twice as long as wide, expanded at each end, and distinctly constricted along the middle, where they are each somewhat carinated on the dorsal side; all pentagonal in form and supporting each two arms on their superior sloping sides, excepting in the anterior ray, where this piece is quadrangular and supports but one arm.

First anal piece wedged obliquely down in between two of the subradials, under one side of the first radial, on its right, and connecting by its left side, above the middle, with another anal resting on a very short truncated side of one of the subradials, and connecting on the left with the first radial of that side. Above these one or two other pieces are seen between the arms, connecting with the base of the proboscis.

Arms somewhat rounded, and bifurcating on the fifth or sixth piece above the second radials; and in all but the anterior ray, one of the divisions (the inner one) remains simple, and the other subdivides again on the sixth, seventh or eighth piece, while the anterior arm bifurcates first on the sixth piece, and each of its subdivisions again on the eighth or tenth piece above. First, and

sometimes also the second arm pieces a little longer than wide, and slightly constricted; other arm pieces generally wider than long and wedge shaped, but not arranged so as to impart a zigzag appearance to the arms. Column small, nearly or quite round, and composed near the base of alternately thin and thick pieces.

Height of body to top of first radial pieces, 0·07 inch; breadth, 0·20 inch; length of arms, about 0·70 inch.

This little species seems to be nearest like *S. dichotomus*, Hall (Iowa Report, p. 553), with which it agrees in size and general appearance. It will be readily distinguished, however, by the more frequent bifurcations of its arms, which also differ in being more rounded and composed of proportionally longer pieces, not arranged so as to present a slightly zigzag appearance, as in the species *dichotomus*. It will also be distinguished from the last by having two arms to each ray all around, as well as by its concave base.

Locality and position. Upper division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 286 of Mr. Wachsmuth's collection.

Scaphiocrinus Tethys, M. and W.

Body under medium size, expanding rather rapidly from the column to the top of the first radials, where it is about one-fourth wider than high. Base small, twice to three times as wide as high. Basal pieces very small, wider than high, and pentagonal in form. Subradial pieces slightly wider than long, pentagonal, excepting two on the anal side, which are hexagonal, there being no well defined angle at the middle of the base of any of them. First radials larger than the subradials, a little wider than long, and all pentagonal. Second radial pieces rather more than twice as wide as long, rounded and a little constricted in the middle, and somewhat expanded at the ends; all pentagonal in outline, and each supporting two arms on its superior sloping sides.

Anal series consisting of two alternating vertical ranges of pieces, the first of which rests between the two upper sloping sides of two of the subradials, and supports an inferior sloping side of the first radial on the right, while its left side above the middle connects with another anal resting upon the truncated upper side of one of the subradials, and connecting with the first radial on the right. Above these one or two ranges of similar pieces join with those forming the base of the so-called proboscis.

Arms not positively known to bifurcate after their origin on the second radial pieces; composed of joints, the lower of which are twice to three times as long as wide, and rounded or subangular, and narrower in the middle than at the ends. Above these the pieces gradually become shorter, and more distinctly expanded at the ends, with the upper lateral extremity of each somewhat projecting alternately on opposite sides, so as to present a distinct zigzag arrangement, the projection being for the support of the pinnulæ, which are comparatively rather stout, and composed of joints two or three times as long as wide, and provided with deep ambulacral furrows within.

Column comparatively rather stout; subpentagonal near the base, but soon tapering and becoming rounded below; composed below of uniform pieces; about one-third as thick as wide, but gradually becoming thinner near the base of the body.

Length of body to top of first radial pieces, 0·17 inch; breadth about 0·22 inch; length of arms, about 1·10 inch.

This species is related to that we have here described under the name *S. nanus*, but not only differs in having longer arms, but in having its second radial pieces and all of its arm joints much longer in proportion, as well as presenting a more strongly zigzag arrangement. Its base is also more protuberant, and the sutures between its body plates slightly impressed instead of even.

Locality and position. Upper division Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 298 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS DELICATUS, M. and W.

Body very small, somewhat cup-shaped, once and a half as wide as the height to the top of the first radials; sides expanding rapidly upward from about the middle of the subradials to the top of the first radial pieces, and rounding under to the column below. Base very small, and nearly hidden by the column, pentagonal in general outline. Basal pieces merely appearing as minute trigonal facets around the top of the column, and curving upward a little at the extremity. Subradial pieces of comparatively rather large size, three or four of them hexagonal (counting a very obtuse angle at the middle of the under side), and one or two heptagonal. First radial pieces of about the size of the subradials, but shorter and wider, and all pentagonal in form; facet of each for the reception of the second radials not occupying the entire breadth above, and sloping outward. Second radials full twice as long as wide, measuring the breadth at the widest part of the lower end; slender and rounded in the middle, and enlarged at the ends, particularly below; each supporting two arms on their upper sloping sides.

Anal plates arranged in a double alternating series, exactly as in the last described species. Arms slender, rounded, and composed of joints, the lower of which are about twice as long as wide, but those above gradually growing shorter, until they become scarcely longer than wide, on the longer side; and owing to their oblique arrangement and projections for the support of the pinnulæ, presenting a zigzag appearance. At least one of the posterior arms seen to bifurcate on the seventh piece. Pinnulæ rounded, comparatively rather stout, composed of joints two or three times as long as wide, and owing to the length of the arm-pieces, widely separated from each other. Column of moderate thickness, and apparently showing a tendency to assume a pentagonal outline near the base.

Height of body to the top of first radial pieces, 0·10 inch; breadth of do. 0·15 inch; length of arms about 0·75 inch.

This very delicate little species is nearest like that we have already described under the name *S. nanus*, but will be readily distinguished by its much more slender second radial pieces and arms. This narrowness of the second radials causes the intervening spaces to be wider than the second radial pieces themselves; while in the *S. nanus* these pieces are so wide as to be in contact with each other all around, excepting on the anal side. These differences give to each of these two forms more strongly marked distinctive features than would probably be apparent from merely reading the descriptions without seeing the fossils themselves.

Locality and position. Upper division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 297 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS CLIO, M. and W.

Body inversely subcampanulate, somewhat truncated or more or less rounded to the column below, and a little expanded at the top of the first radials, where it is nearly twice as wide as high. Base very small, or almost entirely hidden by the column, not projecting below the horizon of the next range of pieces. Subradial pieces slightly tumid, and owing to the small size of the base forming most of the under side, as well as half of the height of the body, a little longer than wide, and all (excepting probably one or two not seen on the anal side) presenting a general pentagonal outline, there being no visible angle at the middle of the under side in any of them. First radials larger than the subradials, wider than long, pentagonal in form, and rounded or convex on the outer side above. Second radials short, transverely oblong, or about twice as wide as long, and all rounded on the outer side. Third radials (in four of the rays seen) somewhat longer than the second, pentagonal in form, but with their lateral margins so short as to appear nearly trigonal; supporting the arms on their superior sloping sides. Anal pieces unknown.

Arms round, rather slender, and after their origin on the third primary radials, bifurcating on the seventh, ninth or eleventh pieces in the different arms seen, and beyond this, one arm is observed to bifurcate on the nineteenth piece above; all composed of slightly wedge-formed pieces, a little wider than long.

Proboscis (so-called), as observed nearly flattened by pressure, two-thirds as wide as the body, and about four-fifths as long as the arms; not expanded at the summit; composed of moderate sized hexagonal pieces indented (and probably perforated) at the corners. Column subpentagonal near the base, where it is composed of alternately thicker and thinner pieces, with a small apparently pentagonal canal.

Height of body to top of first radials, 0·20 inch; breadth, about 0·40 inch; length of arms, about 2·10 inches. Length of proboscis above first radials, 1·70 inches; thickness of column at its connection with the base, 0·15 inch.

This species is related to such forms as *S. carinatus* and *S. dichotomus*, Hall; *S. rusticus*, White, and *S. Wachsmuthi*, M. and W., but differs from them all too clearly to render a comparison necessary.

Locality and position.—Upper division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 295 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS SCALARIS, M. and W.

Body small, somewhat cup-shaped, being broad below, and a little expanded above; about twice as wide as high at the top of the first radials. Base small and hidden by the column in the concavity of the under side. Subradial pieces tumid, wider than high, and arranged so that the body rests upon them, when placed on a plane surface with the column removed; all appearing as if pentagonal, excepting the two on the anal side, which seem to be hexagonal, but they must all have each an additional obtuse angle at the middle of the under side. First radials about of the same size as the subradials, wider than long and pentaganal in form, though one on the anal side has one side so short as to appear as if quadrangular; each a little expanded above, so as to present, with the broad excavations at their inferior lateral angles, a more or less constricted appearance. Second radials smaller than the first, rounded on the outer side, and a little constricted on the lateral margins, all wider than long, with a quadrangular outline. Third radial pieces in all but the anterior ray nearly as large as the first, but proportionally longer, rounded on the outer side, constricted in the middle, and pentagonal in form; the superior lateral sloping sides of each supporting an arm. In the anterior ray the third piece is narrow and long, truncated above, and merely supports a single arm.

First anal piece smaller than the subradials, pentagonal in form, and resting between the upper sloping sides of the two hexagonal subradials; connecting on the left with the second anal, and on the right with a first radial, while it supports one side of another anal above. Second anal of nearly the same size as the first, and resting upon the superior truncated side of the subradial below. Above these, two alternating series of anal pieces are seen extending upward, to connect with the base of the so-called proboscis.

Arms nine, simple from their origin on the third radials, rather angular on the back, and each composed of short wedge-formed pieces, arranged somewhat in zigzag, with their longer ends alternately on opposite sides, and projecting so as to support stout, rounded pinnulæ, composed of joints sometimes nearly as long as wide. Pinnulæ very regularly arranged, so as to leave intervening spaces scarcely of their own breadth, and so stout as to present rather the appearance of armlets, than what are usually called tentacles, in the descriptions of fossil Crinoids; all like the arms with the ambulacral furrows comparatively deep and large.

Vault unknown; proboscis (so-called) about half as long as the arms, comparatively rather slender until at the upper extremity, where it is suddenly expanded to nearly twice its breadth below, and somewhat flattened on top. The

expansion, however, seems to be mainly due to the greater thickness of the plates here, than to a corresponding increase in the size of the cavity within. Plates of the proboscis of moderate size, and all indented at their corners.

Height of body to the top of first radial pieces, 0·18 inch; breadth about 0·32 inch; length af arms beyond the top of the third radials, 1·68 inches; length of proboscis above the first radials, 0 95 inch.

This species is so distinct from all others known to us, that it is scarcely necessary to compare it with any of them. It seems to be most like *S. Halli*, Hall, but differs in having its subradials so tumid as to give the body a truncated appearance below, instead of an inversely campanulate outline. Its pinnulæ are also much stouter and less oblique, while its arms are entirely without the little flattened spine-like projections along their backs seen in that species. The stout pinnulæ as seen extending between the arms present, with the latter, a peculiar scalariform appearance, that suggests the specific name.

Locality and position. Upper division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 282 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS FISCELLUS, M. and W.

Body very small, somewhat cup-shaped, about once and a half as wide as high, rather broad and subtruncated below, with moderately expanded sides. Base very small, flat, and hidden by the column, when the latter is attached. Subradial pieces convex, curving under to connect with the base and extending about half way up the sides; three of them presenting a pentagonal outline, and two hexagonal, (that is without counting a very obtuse angle doubtless existing at the middle of the under side of each, but hidden by the column). First radials about the size of the subradial pieces, and pentagonal in form, the upper side always truncated the full breadth. Second radials quadrangular, constricted in the middle, and expanded at the ends; separated from each other by spaces nearly half their own breadth, measuring at the middle. Third radial pieces a little longer and narrower than the second, abruptly dilated at the ends, and strongly contracted in the middle; each, with apparently the exception of one in the anterior ray (which seems to bear only one arm), supporting two arms on their superior strongly sloping sides.

Anal plates forming a double alternately arranged series, exactly as in the last. Arms apparently simple from their origin on the third radials; composed of pieces as long as wide, or a little longer, and angular on the dorsal side; each piece always contracted in the middle, and expanded at the ends, particularly at one of the upper lateral corners alternately on each side of the arm, for the reception of the pinnulæ, thus giving the arms a zigzag appearance. Pinnulæ rather stout, and composed of pieces about as long as wide.

Surface of the body with deep indentations at the corners of all the plates, so as to form a comparatively strong ridge radiating to each side of the subradial pieces, to connect with a similar one on each of the adjacent pieces.

Height of body about 0·11 inch to the top of the first radial pieces, where it measures about 0·17 inch in breadth; length of arms, about 0·95 inch.

This species is nearly related to the last, but in addition to being much smaller, it differs in the strong radiating costæ of its body plates, as well as in having its subradial plates merely convex, instead of tumid. Its arm joints also differ in being proportionally longer, and contracted in the middle.

Locality and position.—Lower division of the Burlington group; Burlington, Iowa. Lower Carboniferous. No. 283 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS JUVENIS, M. and W.

Body small, expanding rather rapidly from the column, or presenting a short, obconic form, with rather distinct sinuses between the radial series; nearly twice as wide at the top of the first radials, as the height to the same point. Base small and short, or several times wider than high, but projecting

below the subradials, truncated about three-fourths its breadth by the facet for the attachment of the column. Basal pieces nearly twice as wide as long, and pentagonal in form, but owing to the shortness of the lateral margins appearing nearly trigonal. Subradial pieces a little wider than long, three pentagonal, and two on the anal side hexagonal (without counting a scarcely defined angle at the middle of the under side of each). First radial pieces of about the size of the subradials, generally wider than long, and pentagonal in form. Second radials about as long as wide, distinctly rounded on the dorsal side, and quadrangular in outline. Third radials somewhat larger than the second, more or less expanded at the upper end, and rounded and contracted in the middle ; each bearing two arms on its superior sloping sides.

Anal plates forming a double alternating series of five or six pieces, as in the last; the lowest piece resting between the upper sloping sides of two of the subradials, partly under the first radial on the right, and connecting on the left above the middle, with another piece resting upon the upper truncated edge of one of the subradials, and joining the first radial on the left.

Arms ten, simple from their origin on the third radials, composed of somewhat wedged-formed pieces, about as long as wide on the longer side, which projects above, alternately on opposite sides of the arms, for the reception of the pinnulæ, so as to present a somewhat zigzag appearance. Pinnulæ stout, arranged at intervals of near their own breadth apart, and composed of joints that are about as long as wide. Surface granular ; body plates even, and merely separated by linear sutures. Column of comparatively moderate size, faintly subpentagonal, near the base, and composed of rather thin, nearly equal plates, with a very small central perforation.

Height of body to the top of first radial pieces, about 0·12 inch ; breadth, 0·20 inch ; length of arms, about 0·75 inch ; thickness of column at base, near 0·07 inch.

This species is related to the last two, but is readily distinguished by the more conical form of its body, produced by the protuberance of its base, as well as by having two arms to each ray all around, instead of only one in the anterior ray. It also differs from both in having its body plates even, instead of very convex, or tumid, as in *S. scalaris*, or costate, as in *S. fiscellus*.

Locality and position.—Lower division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 284 of Mr. Wachsmuth's collection.

SCAPHIOCRINUS NOTABILIS, M. and W.

Body large, obconic, or expanding gradually from the column to the middle of the first radials, at which point these pieces are protuberant, so as to give the general outline, (as seen in a side view) a tendency towards an inverted bell-shape. Base of a deep cup form, less than twice as wide at the top as the height, or about one-third as high as the body to the top of the first radials. Basal pieces higher than wide, and pentagonal in form, the lateral margins being longest. Subradial pieces nearly twice as long as the basal, hexagonal in form, excepting the two on the anal side, which are heptagonal. First radials somewhat larger than the subradial pieces, slightly wider than long, pentagonal in form, and each provided with a very profound sinus for the reception of the second radials, more than one-third as wide as its upper edge, and extending about half way down its outer side. Second radial pieces comparatively very small, or about one-third as large as the first ; pentagonal in form, about as wide as long, rounded on the outer side, and so deeply inserted in the sinus of the first radials on a kind of shoulder-like projection, that their mesial angle above scarcely rises beyond the upper margins of the first radials, each supporting two arms on its superior sloping sides, and separated from that of the next ray on each side, by an interradial space of about one and a half its own breadth. Anal plates two and about half of the third, included as a part of the walls of the body, hexagonal in form, and having the usual arrangement of those of *Poteriocrinites*, in a double, vertical, alternating series.

Arms very long, slender and rounded; one of them seen to bifurcate first on the sixth, two others on the eighth, and another on the tenth piece, above the second radials. Beyond these bifurcations it is evident from the number of slender branches seen, that there must be other subdivisions, but the specimen is not in a condition to show the details of the bifurcations. Arm pieces generally longer on the longer side than wide, but not arranged in zigzag; the first two of each arm twice as long as wide, and somewhat contracted around the middle. Proboscidiform extension very long, or nearly or quite equaling the length of the arms, and somewhat narrowed at the extremity.

Surface of the first radial plates strengthened by prominent, rounded, radiating costæ, two of which diverge downward from the mesial prominence under the sinus for the second radials, to connect with others on the subradials, so as to inclose profound triangular pits at the upper corners of the latter; while two similar ridges run laterally on each side of the sinus, paraller to the upper margin, to connect with those similarly situated on each adjacent first radial. On each subradial, the ridge extending down the middle widens and becomes nearly obsolete at the base, where it connects with several slender lines that continue on down converging toward the lower part of each basal piece; there being no pits or impressions at the meeting of the corners of the basal and subradial pieces.

Height of body to the top of the first radial, 0·96 inch; breadth across at the most protuberant part of the first radials, about one inch. Length of arms from their origin on the second radials, about four inches. Length of proboscidiform ventral extension, 3 85 inches.

This fine species departs very widely from the typical forms of *Scaphiocrinus* in its large size, obconic body, strongly costate body plates, long bifurcating arms, and particularly in having its second radial pieces so narrow in proportion to the first, as to be separated from each other by interradial spaces, wider than the second radial pieces themselves. Its anal series, although including more pieces than we see in the *typical Scaphiocrinus* (being like that of *Poteriocrinites* proper), does not differ from that of a large proportion of the species usually included in *Scaphiocrinus*, with which the species agrees in having only two radial pieces to each ray.

Specifically it is related to such forms as *Cyathocrinus macropleurus*, Hall, and *Poteriocrinus obuncus*, White; but it differs too widely from these and all the other similar forms known to us, to render a comparison necessary. *Cyathocrinus macropleurus* was described from a specimen not showing either the anal pieces or second radials, or the arms; Mr. Wachsmuth has specimens, however, showing that it has several anal pieces, and two radials to each ray. He also has specimens of the *P. obuncus* (which was also described from a specimen not showing the arms and second radials), indicating that it agrees in these characters with *Scaphiocrinus*. It is possible such species should form a separate section, or subordinate group.

Locality and position.—Lower division of the Burlington group, Burlington, Iowa. Lower Carboniferous. No. 303 of Mr. Wachsmuth's collection.

Scaphiocrinus Coreyi, M. and W.

Body of medium size, basin-shaped, or about twice as wide as high, rounded and distinctly concave below. Base small, and nearly or quite hidden by the column in the concavity of the under side. Subradial pieces comparatively rather large, curving under to connect with the base, all presenting a general hexagonal outline, excepting two on the anal side, which are heptagonal; they must each, however, have another obscure angle below. First radial pieces about equaling in size the subradials, but proportionally wider, being sometimes slightly more than twice as wide as long, all pentagonal in form, the upper side being much the longest, and the lateral margins short. Second radials a little longer than the first, but narrower above, and more or less con-

stricted around the middle; pentagonal in form, the upper angle being rather salient, and each supporting an arm on each of their superior sloping sides. First anal piece about one-third as large as one of the subradials, hexagonal in form, and resting between the upper sloping sides of two of the subradials, and partly under one side of one of the first radials on the right; while it supports another anal piece above, and connects with a third on the left, which rests upon the upper truncated side of one of the subradials.

Arms moderately long, carinated along the middle of the outer side, and after the first division on the second radials dividing again on the sixth or eighth piece, beyond which they are all simple; each composed of alternating wedge-shaped pieces, which are a little wider than long, and each projecting on alternate sides above for the reception of tentacles, which are stout, angular, and composed of pieces nearly twice as long as wide.

Breadth of body, 0·55 inch; height to top of first radials, about 0·20 inch.

This species is remarkable for the curious rough appearance of the arms, produced by the projection of the pieces alternately on each side, and the interruption of the carina along the dorsal side, which is not continuous, but looks as if the pieces had been slipped a little alternately to opposite sides.

Locality and position.—Crawfordsville, Indiana. Keokuk division of the Lower Carboniferous.

Subgenus ZEACRINUS.

ZEACRINUS SCOBINA, M. and W.

Body very much depressed, or about four times as wide as high, to the top of the first radial pieces, and concave in the middle below. Base small, and hidden by the column in the concavity of the under side. Subradial pieces curving in to the concavity of the under side, and extending outward around the column; all presenting a nearly pentagonal general outline, with short lateral edges, excepting the one on the anal side, which seems to be hexagonal, (each being without a visible angle at the middle of the under side). First radials three or four times as large as the subradials, near twice as wide as long, pentagonal in form, with lateral and inferior margins of nearly equal length, and upper edge equaling the entire breadth. Second radials as wide as the first and nearly twice as long, all pentagonal in form, the superior angle being salient, and also projecting outward, while a strongly defined mesial angle extends down the middle of the dorsal or outer side to the base of each, the surface on each side of this angle being distinctly concave.

Anal pieces small, and owing to the rough surface of the plates, and the indistinctness of the sutures, without very clearly defined outlines. As near as can be made out, the first one seems to be somewhat cuneiform, and wedged in obliquely under one side of the first radial on the right; on its left it connects above the middle, apparently with another resting upon a very short upper side of one of the subradials. Above these other anal pieces are seen between the arms, but their exact arrangement cannot be made out from the specimen studied.

Arms, after their origin on the second radials, each bifurcating on the sixth piece (excepting those of the anterior ray, which divide first on the eleventh piece), the inner division of each being smaller than the other, and remaining simple; while the outer or main arm gives off another division on the inner side on the eighth piece above the first bifurcation, and still another on the ninth or tenth piece above the latter, which is as far as the arms can be clearly traced in the specimen, though there is some appearance of a fourth bifurcation in one of the arms. Arm pieces short, or from twice to three times as wide as long, and not in the slightest degree wedge-shaped; each with lateral edges sharp and a little projecting, and provided with a little pointed process on the middle of the dorsal side. These little asperities, and the beveled character of the sutures between the arm joints, give the arms a rough,

rasp-like appearance, which has suggested the specific name. The body plates are also rendered very rough by a ridge extending from the middle of the upper edge of each first radial to connect with others on the subradials, and the presence of other irregular asperities. Sutures between the first and second radials widely gaping when the arms are folded together. Column of moderate size, and composed of thin, nearly round pieces, with projecting rough edges, and a rather small subpentagonal central perforation.

Height of body to the top of the first radials, 0·10 inch: breadth, about 0·42 inch; length of arms, about 1·70 inch.

This species is related to *Zeacrinus perangulatus*, of Dr. White, but differs in having its arms longer and less tapering, as well as bifurcating more frequently; also in having each inner division of each arm smaller than the outer. The bifurcating pieces of its arms are likewise proportionally smaller, and not protuberant as in that species. In the species *perangulatus* the arm pieces are also merely angular along the middle, while in that under consideration there is, instead of a continuous angle, a row of little pointed isolated protuberances, presenting a crenate appearance as seen in outline.

Locality and position. Upper division of the Burlington group, Burlington, Iowa. Lower Carboniferous. No. 321 of Mr. Wachsmuth's collection.

ZEACRINUS ASPER, M. and W.

Body small, much depressed, or twice and a half as wide as high, broadly truncated and concave below, the concavity including the base and about half the length of each subradial piece. Base small and nearly or quite hidden by the column. Subradial pieces very abruptly geniculated in the middle, the lower or inner half forming a part of the concavity of the under side, and the upper a part of the outer wall of the body, while their prominent middle forms the margin of the concavity below, each presenting a pentagonal outline, excepting one on the anal side, which is hexagonal. First radial pieces about twice as long as the subradials, and twice as wide as long, all pentagonal in form, with the upper truncated side equaling the full breadth. Second radial pieces as wide and once and a half as long as the first, pentagonal in form (unless the anterior one, which has not been seen, may be an exception), and supporting the arms on their superior sloping sides, each with a very prominent sharp carina extending up the middle, while the surface on each side of the carina is deeply concave, excepting at the lower margin, along which there is also a transverse ridge or carina.

Anal plates arranged as in the last described species, in a double alternating series, the lower one being placed obliquely under one side of the first radial on the right, while the next rests upon a short end of one of the subradials, the two connecting together and supporting the others above.

Arms, after their origin on the second radial pieces, each bifurcating on the sixth piece, the two divisions of each being of equal size, but the inner one is simple, while the outer bifurcates again on the sixth, seventh, eighth or ninth piece above the first division, beyond which the two equal divisions are simple as far as they can be traced in the specimens examined. Arm pieces short, or nearly twice as wide as long, wedge form, and each strongly projecting on the longer side, alternately, so as to present a zigzag appearance; bifurcating pieces all larger than the others, and extending out, on the dorsal side of the arms, into pointed prominences, sometimes assuming the character of short spines, which, with the lateral processes of the other pieces, give the arms a very rough, harsh appearance.

Surface of the body plates with deep excavations at the corners, and strong ridges or carinæ between the excavations. Of these carinæ, two descend diverging from the middle of the upper side of the first radials (along which there is also a transverse ridge), to connect with others on the subradial pieces. Sutures between the first and second radial pieces very widely gaping. Column round and very slender near the base, where it is composed of pieces

of moderate thickness, every alternate or third one of which projects out distinctly beyond the others. Central canal minute and apparently round.

Height of body to the top of the first radial pieces, 0·10 inch; breadth, 0·31 inch; length of arms, about 1 inch.

This is another species related to *Zeacrinus spinobrachiatus*, of Dr. White, but it differs in having decidedly more slender arms below the bifurcations, with the arm pieces, particularly above the first bifurcation, arranged much more in zigzag, and their thicker ends more projecting on each side. It is one of the forms combining some of the characters of *Zeacrinus* and *Scophiocrinus*.

Locality and position. Upper division of the Burlington group, Burlington, Iowa. Lower Carboniferous. No. 323 of Mr. Wachsmuth's collection.

ZEACRINUS SERRATUS, M. and W.

Body small, much depressed, or about three times as wide as high, broadly truncated and concave below. Base very small, and nearly or quite concealed by the column in the concavity of the under side. Subradials a little tumid, curving abruptly into the concavity of the under side, and extending about half way up the lateral walls of the body; three or four pentagonal and one or two on the anal side hexagonal (not counting a very obtuse angle doubtless existing at the middle of the under side of each). First radials somewhat larger than the subradials, nearly twice as wide as high, and all pentagonal in form, with the upper side equaling the entire breadth. Second radials as wide at the base as the first, and nearly twice as long, each pentagonal in form and supporting two arms, excepting that of the anterior ray, which is quadrangular and supports but a single arm; each with a prominent, well defined, sharp carina extending up the middle, and the dorsal surface on each side of this carina is distinctly concave. Anal pieces arranged in a double alternating series almost exactly as in the last.

Arms (excepting in the anterior ray) bifurcating first on the sixth piece above their origin on the second radials, the inner division being slightly smaller than the other, and simple to the end, while the outer division bifurcates again on the seventh piece above, and a third time on the eighth piece above the latter, the inner divisions being all simple. Arm pieces very short, or two or three times as wide as long, and scarcely showing any tendency to assume a wedge shaped outline; each one with a small pinched or angular projection on the middle of the dorsal side, giving the arms a subcarinated appearance; but these projections are not continuous, being separated by notches at the sutures between the pieces, and a little inclined upward, so as to impart to the dorsal side of the arms a serrated appearance, as seen in an outline lateral view. Axillary pieces at all the bifurcations of the arms larger than the other arm pieces, and more prominent and angular.

Surface of body plates merely convex, or somewbat tumid, and without costæ or carinæ. Column very small, round or subpentagonal, and composed, near the base, of nearly equal rather thin pieces, with a very minute central perforation. Sutures between the first and second radial pieces widely gaping.

Height of body, 0·07 inch; breadth, about 0·22 inch; length of arms, about 0·60 inch.

In several respects this species agrees almost exactly with *Z. ramosus*, of Hall, which has the same proportions, with its arms bifurcating in exactly the same way, and composed of similar short pieces, showing no tendency to a wedge formed outline. On comparison with the original typical specimen of that species, however, now before us, the species under consideration is found to differ in having its second radial pieces each provided with a sharp, strongly defined mesial carina, and the surface on each side of the carina distinctly concave, instead of having these pieces merely obtusely rounded. The same or a similar difference is also seen in the arm pieces, each of which is provided with one or more little projections on the dorsal side, instead of being smoothly

rounded or somewhat flattened, as in *Z. ramosus*. If it were not for the fact that the typical specimen of *Z. ramosus* has the surface well preserved, we would be led to think it might possibly have possessed the sharp carina of the second radials, and the projecting points of the arm pieces, seen in the species under consideration, and that they might have been removed by accidental abrasion. The fact, however, that it has the surface of its arms, second radials and other parts so well preserved as to show the original fine, delicate granulations over the whole, demonstrates that it could never have possessed the characters mentioned in the species we have here described; and as we have never seen varieties of a species, in this or any of the allied groups, differing to this extent in such characters, we can but regard the differences as being specific.

It will be observed that the character of the arm and second radial pieces, mentioned as distinguishing this species from *Z. ramosus*, also occur in the species described in this paper under the name *Z. scobina*. That species, however, differs from this in having its first radials and subradial plates strongly costate, while its arms are proportionally longer and differ in being somewhat serrated on each side. It also differs in having two arms, instead of only one, from the anterior ray, as in this, and more divisions in its arms, which divisions are given off at greater intervals.

Locality and position. Burlington group, at Burlington, Iowa. Lower Carboniferous. Mr. Wachsmuth's collection.

ZEACRINUS LYRA, M. and W.

Body short obconical, or expanding very rapidly from the column to the top of the first radial pieces, where it is about twice as wide as high. Base not concave but somewhat projecting, and about one-third as high as wide; truncated near three fourths its breadth by the slightly concave facet for the attachment of the column. Basal pieces presenting a small pentagonal facet above the column, two or three times as wide as long, with lateral margins so short as to appear nearly triangular. Subradial pieces of moderate size, about as wide as long, three hexagonal and two on the anal side heptagonal. First radial pieces generally about twice as large as the subradials, near once and a half as wide as long, and all pentagonal, with the upper side equaling the entire breadth. Second radial pieces of very nearly the same size and form as the first, though the fifth angle and sloping sides are of course above instead of below; each supporting two arms, all around. Anal plates nearly all hexagonal, and, as usual, arranged in a double alternating series, the first resting between the superior sloping sides of two of the subradials, under one side of the first radial on the right, and connecting above the middle on the left, with another resting on the superior truncated side of one of the heptagonal subradials, and joining the first radial on the left. Above these the others extend up to connect with the proboscis (so called).

Arms all distinctly rounded, and after their origin on the second radial pieces each bifurcating first on the fifth, sixth, seventh or eighth piece, above which the outer division bifurcates (or gives off an arm on the inner side) twice or three times at more or less nearly equal distances, all the inner arms continuing simple throughout their entire length, and equaling the outer divisions in thickness. Arm pieces short and very distinctly wedge formed, each having a moderately stout tentacle at its larger end, along the inner lateral margins of the arms; axillary or bifurcating pieces a little larger than the others, but not more convex. Tentacles composed of joints about twice as long as wide.

Body plates not convex, and merely separated by linear sutures, which are not gaping even between the first and second radials; entire surface more or less granular.

Height of body to top of first radials, about 0·25 inch; breadth, about 0·50 inch; length of arms, apparently nearly 2 inches.

This species is related to *Poteriocrinus bursæformis*, of White, which has its body formed exactly as in *Poteriocrinus*, with its arms and primary radials presenting all the characters of *Zeacrinus*, as was noticed by Dr. White; thus showing, with the species under consideration and some others, that *Zeacrinus* can scarcely be regarded as more than a subgenus under *Poteriocrinites*. The form that we have here described differs, however, specifically from Dr. White's species, in having its body proportionally shorter and smaller. Its arms also differ in being very distinctly rounded instead of flat, while its anterior ray supports two arms directly on the second radial piece, as in all the other rays, instead of having the first bifurcation in that ray on the fourth piece.

The specimens are not in a condition to show much of the ventral prolongation, but one of them shows that it is very nearly as long as the arms, and somewhat expanded and crowned with short spines at the upper extremity.

Locality and position. Upper division of the Burlington group, at Burlington, Iowa. Lower Carboniferous. No. 319 of Mr. Wachsmuth's collection.

Genus ACTINOCRINITES, Miller.

In the second volume of the Illinois Reports, published in 1866, after admitting as distinct genera from *Actinocrinites* the groups *Megistocrinus*, *Agaricocrinus*, *Amphoracrinus* and some others, we also separated under the name *Strotocrinus* a group of remarkable American Carboniferous species, of which *Actinocr. perumbrosus*, Hall, was regarded as the type. At the same time that we made this separation there were amongst the collections before us specimens of another allied type, in regard to the proper disposition of which we were in considerable doubt. These belong to the group of which *A. ventricosus*, Hall, may be regarded as an example. We readily observed that while in some of their characters they agree most nearly with *Strotocrinus*, that in others they seemed to be more closely allied to *Actinocrinites*, and at one time we were very much inclined to the opinion that a strictly systematic definition of all the different genera of the *Crinoidea* would require their separation as a distinct intermediate genus. Wishing to avoid disturbing the existing nomenclature, however, as much as possible, we finally concluded to place this group provisionally as a section under *Actinocrinites*.

Since that time we have had an opportunity to study an extensive series of these and the allied groups, in Mr. Wachsmuth's collection, and have been led to the conclusion that if this type does not form a separate genus, holding an intermediate position between *Strotocrinus* and *Actinocrinites*, that it should be placed as a distinct subgenus under the former. Adopting this view, and admitting, as we have elsewhere done, that the *Batocrinus* and *Dorycrinus* groups should stand as distinct genera, the genus *Actinocrinites* would be left to include two sections;* that is, the typical forms, such as Miller's *A. triacontadactylus* and *A. polydactylus*, and de Koninck's *A. stellaris*, *A. diversus*, *A. deornatus* and *A. armatus*, with various others; and the group including *A. multibrachiatus* and its allies.

The typical forms of *Actinocrinites*, which agree almost exactly with all the other genera mentioned, as well as with the *A. multibrachiatus* group, in the number and arrangement of the pieces composing the walls of the body below the bifurcations of the rays, are distinguished by the following characters, never found all combined in any one of the other groups:

In the first place, they have the arm bases, or brachial pieces, and adjacent parts (sometimes as far in as the third primary radials) grouped together so as to form five more or less protuberant lobes,† and so far as yet known to us, at

* There are doubtless other sections, but we allude here to the forms we have had an opportunity to study.

† Since these remarks were in type, we observe, on consulting Miller's Nat. Hist. of the *Crinoidea*, to which we had not previously had access for many years past, that he seems to have confounded two very distinct forms under the one name of his typical species, *Actinocrinites triacontadactylus*. One of these, *if correctly represented on plate I of his work*,

least a part of the arms bifurcating *after* becoming free, and always each composed of a single series of pieces below each bifurcation, as well as generally for some little distance above. They also combine with these characters a more or less produced central or subcentral tube or proboscis, and have the second primary radial pieces nearly always normally hexagonal.

The other group represented by *A. multibrachiatus* differs from the typical forms of *Actinocrinites* in having the arm bases arranged in a nearly or quite continuous series all around, and the arms *never* bifurcating *after* becoming free, as well as in nearly always having normally the same number of arms in each ray. The species of this group also more generally have the vault higher in proportion to the body below the arms, but there are a few exceptions to this in both groups. In a few species of typical *Actinocrites* the arm bases are less distinctly grouped, and not so protuberant as in others, but so far as we have yet seen they can readily be distinguished by the structure and bifurcations of their arms, where specimens retaining them can be seen, and nearly always, even where the arms are broken away, by their wider interradial and anal sinuses and other peculiarities of general physiognomy, apparent enough to the eye but difficult to express in words.

In having the arm bases arranged in a nearly or quite continuous series all around, and the arms never bifurcating after becoming free, the *A. multibrachiatus* group agrees with *Batocrinus*, but it differs from that group in having longer arms in proportion to the length of the proboscis, which in *Batocrinus*, when entire, protrudes from one-fourth to one-half its entire length beyond the extreme length of the arms.* They also differ from *Batocrinus* and agree with *Actinocrinites* in nearly always (perhaps always normally) having the second radial pieces hexagonal instead of quadrangular, while their body plates are more or less sculptured (generally strongly so) into radiating costæ, usually consisting of a single rib for each side of each plate, instead of having the plates even and smooth, merely convex or tumid. In short, the species of these two groups can be distinguished at a glance from specimens even showing the body only.†

As thus limited, the genus *Actinocrinites* would include, along with a number of foreign species, the following American Carboniferous forms:‡

1. ACTINOCRINITES, Miller. *Section* (*a*).

A. verrucosus (= *A. asterius*, McC.), *A. chloris* (= *A. tenuisculptus*, McC.), *A. lobatus*, *A. Humboldtianus*, *A. jugosus*, *A. pernodosus*, *A. unicostatus*, *A. Lowei*, *A. brontes*, &c., of Hall. Also, *A. Yandelli* and *A. multiradiatus*, Shumard; *A. Wachsmuthi*, White; and *A. scitulus*, M. and W. (= *A. rusticus*, Hall, and *A. Sillimani*, M. and W.); as well as our *A. penicillus* and *A. delicatus*, of this paper, and *A. Indianensis*, L. and C., with perhaps several others with which we are not very well acquainted.§

2. *Section* (*b*).

A. multibrachiatus, *A. proboscidialis*,‖ *A. cælatus*, *A. clavus*, *A. limibrachiatus*,

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must belong to an entirely different species from that figured under the same name on his plate II, as it is represented as having its arm-bases and contiguous parts, not forming five widely separated protuberant lobes, but arranged more like those in the American section represented by such forms as *A. multibrachiatus*, though its arms clearly bifurcate *after* becoming free.

* See figs. 1 and 2, pl. 11, Iowa Geo'l Report, vol. 1, pt. ii.

† See pl. x, fig. 10, Iowa Geol. Report, vol. 1, pt. ii. For other examples of this group see figs. 13 & 14 same plate, where they may be compared with figs. 7 & 9 of the same plate, representing two species of true *Actinocrinus*, with arm bases grouped into 5 protuberant lobes.

‡ There are some other described American species not mentioned in this list, which is only intended to include such species as we have had an opportunity to study.

§ Dr. Shumard's *A. concinus* belongs here, if not a *Steganocrinus*. We have not yet seen a specimen of it showing the rays far enough out to decide positively to which of these groups it belongs.

‖ *A. quaternarius*, *A. quaternarius var. spiniferus* and *A. Themis*, Hall, are believed to be varieties of his *A. proboscidialis*.

A. ovatus, *A. securus*, *A. opusculus*, *A. excerptus*, *A. infrequens*, *A. thalia*, *A. thetis*, *A. thoas*, *A. locellus*, *A. sexarmatus*, *A. reticulatus*, all described under *Actinocrinus* by Prof. Hall. Also, *A. Fosteri* and *A. Hurdianus*, McChesney, and our *A. longus* of this paper.

It is worthy of note that all the known Burlington species of this group came from the Lower Burlington beds, as has been determined by Mr. Wachsmuth, by careful observations continued through many years.

ACTINOCRINITES. *Section* (*a*).

Actinocrinites penicillus, M. & W.

Body small, inversely campanulate, or with sides expanding rapidly from the truncated base to the secondary radius, which with the brachial pieces curve a little outward. Base much depressed, or about four times as wide as high, broadly truncated and but slightly concave below; margin more or less expanded horizontally, and deeply notched at the sutures. First radial plates comparatively rather large, and about twice as wide as high. Second radials near half as large as the first, about twice as wide as high. Third radials a little larger than the second, wider than long, and pentagonal in form, the lateral margins being short, each supporting on each of its superior sloping sides a secondary radial of about its own size, which in its turn supports two free arms.

Anal pieces unknown above the second range; first one smaller (particularly narrower) than the first radials, and supporting two others of its own size in the next range. Interradial pieces three to five in each space; first one as large as the second radials, hexagonal in form, and bearing upon its upper sloping sides two smaller pieces, above which there is generally one or two minute pieces.

Arms free from their origin on the secondary radials, and composed below of slender rounded pieces, the first of which is about twice as long as wide, and more or less constricted in the middle; beyond this the lateral arm on each side of each ray is simple, with its second piece like the first, and followed by two or three other shorter wedge formed pieces before passing into a double series of small, alternately arranged pieces. Inner arms of each ray bifurcating on the first piece, and one of the subdivisions in one or both bifurcating again on the first piece, thus making from seven to eight arms to each ray, or from thirty-five to forty in the entire series. The single piece below and the first above each division, is slender, rounded, and more or less constricted, and generally two or three wedge formed pieces follow the latter before the commencement of the double series of alternating pieces, above which the arms are a little wider and of moderate length. Vault unknown; proboscis very slender at the upper end, and apparently of about the same length as the arms.

Surface of all the body plates deeply excavated at the corners, and prominent in the middle, the prominence of the first radials usually forming a transverse ridge, from which a single more or less defined vertical ridge ascends the second radials to the middle of the third, from which it bifurcates and continues to the secondary radials.

Height of body to the top of secondary radials, about 0·22 inch; breadth at the top of secondary radials, 0·40 inch; length of arms if straightened out, about 0·70 inch; breadth of do. at the widest part near the middle, 0·05 inch.

This little species is allied to *A. lucina*, Hall, which, before seeing specimens showing the arms, we had supposed to belong to the *A. multibrachiatus* group, but which is a true *Actinocrinites*. Our species differs, however, in having the arms more frequently and differently bifurcating, so as to make from thirteen to fifteen more in the entire series. Its arms also difier in not being subspinous on their margins.

Locality and position. Lower Burlington beds of Lower Carboniferous, Burlington, Iowa. No. 38 of Mr. Wachsmuth's collection.

ACTINOCRINITES DELICATUS, M. and W.

Body small, subturbinate, or widening rather rapidly from the somewhat truncated base to the top of the third radials. Base depressed, or about four or five times as wide as high, with slightly expanded margins notched at the sutures. First radial pieces of moderate size, a little wider than long, and, as usual, two heptagonal and three hexagonal. Second radial pieces a little smaller than the first, more or less regularly hexagonal, the superior lateral sides, however, being sometimes very short. Third radials about as large as the second, normally pentagonal, but sometimes with the lateral angles truncated so as to give them an irregular heptagonal outline. Secondary radials resting one upon each superior sloping side of each third primary radial, which they exceed in length; more or less prominent, curving outward, and generally constricted and rounded in the middle, though not entirely free from the walls of the body, excepting on the upper side; supporting on each of their superior (free) sloping sides the first divisions of the arms. First interradial pieces about as large as the first radials, hexagonal, and supporting two smaller pieces in the next range, which connect with others above, belonging apparently more properly to the vault. First anal piece nearly as large as the first radials, heptagonal in form, and supporting in the second range two pieces, one of which (in the typical specimen) is as large as the first; above these there are four or five smaller irregular pieces in the third range, and above the latter others belonging apparently to the vault.

Arms slender, rounded, and composed below of distinctly constricted pieces longer than wide, and, after the first division on the secondary radials, the inner ones bifurcating on the second piece, and one or both of these subdivisions divide again on the second piece, above which they still continue to be composed of a single range of rounded pieces for a short distance, and then pass gradually through a few wedge-formed pieces into a double series of alternating pieces; above this they are all a little stouter than below, and show a very slight tendency to become somewhat flatter toward their upper extremities. So far as can be seen, the two outer arms of each ray are simple from their origin on the secondary radials, and composed of a single series of rounded and constricted pieces as far up as the last bifurcations of the other arms; consequently there appear to be eight ultimate divisions, or arms, to each ray. (Vault unknown.)

Surface apparently minutely granular, and with a small, more or less defined ridge extending from the base up the primary radials to the third radial, on which it bifurcates and sends a branch to the base of each of the two main arms. On the first radials, as well as the anals, there is also some tendency to send off an obscure ridge across from one to another, on each side. None of the body plates are tumid, though they are generally very slightly convex.

Height of body from bottom of base to the top of secondary radials, 0·16; breadth, about 0·30 inch.

This species is related to *A. chloris*, Hall, but is much smaller, and differs in having its body, below the arms, merely rather rapidly expanding, with nearly straight sides, instead of being hemispherical. Its arms also bifurcate differently. In the *choris*, for instance, they all (or at any rate, the inner ones), after their origin on the secondary radials, bifurcate once on the first piece beyond, while in our species the inner arms bifurcate on the second piece, and the outer of those subdivisions again on the second piece.

Locality and position.—Upper division of the Burlington member of the Lower Carboniferous at Burlington, Iowa. Mr. Wachsmuth's collection.

ACTINOCRINITES. *Section* (*b*).

ACTINOCRINITES LONGUS, M. and W.

Body rather elongate-obconic below the arms, the sides expanding gradually, with a moderately convex outline from the base to the tertiary radial pieces, which, with the brachial pieces, curve very slightly outward. Base about twice and a half as wide as high, not thickened or expanded below, and but very slightly notched at the sutures; facet for the reception of the column large and moderately concave, with a rather large central perforation. First radials comparatively large, very nearly or quite as long as wide. Second radials scarcely half as large as the first, about as wide as long, quadrangular, pentagonal or unequally six-sided. Third radials of about the same size as the second, pentagonal, hexagonal, or heptagonal, and each bearing on its superior sloping sides two secondary radials of near its own size, each of which supports, on its outer sloping upper side, brachial pieces, leading to an arm, and on its inner side, above, a small tertiary radial giving origin to two arms, thus making three arms to each main division, and six to each ray, or thirty to the entire series. (Arms nnknown.)

Anal plates five or six, the first being of the same size as the smaller first radials, hexagonal in form, and a little longer than wide; second anals two, about two-thirds as large as the first, and irregularly heptagonal or octagonal; above these there are two smaller pieces in the third range, and one or two still smaller pieces above the latter, the upper one being barely large enough to separate the posterior lateral brachial pieces of the two posterior rays. First interradial pieces about half as large as the first radials, heptagonal, and supporting two smaller pieces in the second range, above which there are one or two still smaller pieces in the third, and a minute piece over the latter, wedged in between the brachial pieces. In each interaxillary space there are usually two intercalated pieces, the lower of which is sometimes as large as one of the tertiary radials, while the upper is very small, and wedged in between the brachial pieces.

Vault conical, and nearly three-fourths as high as the body below the arms; composed of irregular pieces of moderate size, some of which project in the form of small pointed nodes or short spines, passing gradually into a rather large subcentral proboscis.

Surface of all the body plates rather distinctly convex, but not properly tumid, and showing but the faintest traces of an effort to form, on some of the smaller pieces, an obscure radiating ridge near each side. In most cases, however, these are entirely obsolete, and the plate seems to be merely evenly convex.

Height of body to arm bases, 1·20 inch; breadth of do. at arm bases, 1·40 inch; height of vault, about 0·80 inch.

In the structure of its body, as well as in its arm formula, this species agrees with *Actinocrinus clavus*, of Hall. It differs, however, greatly in form, as well as in the surface characters of its body plates, being rather elongate obconical below the arms, instead of "very broadly subturbinated, and spreading more rapidly above the third radial plates;" while its body plates are merely convex, instead of being "elevated into strong angular nodes, some sometimes marked by low ridges on the lower part," and by "strong angular ridges" on the upper part.

Its elevated conical vault, passing gradually into the nearly central proboscis, and narrow obconic body below the arms, give it a peculiar fusiform outline. In the nature of its vault it resembles quite nearly *A. costatus* of Hall, from which, however, it differs widely in other respects.

Locality and position.—Lower beds Burlington group of Lower Carboniferous, Burlington, Iowa. Mr. Wachsmuth's collection.

Genus STROTOCRINUS, M. and W. 1866.*

Extending the genus *Strotocrinus* so as to include, as already suggested, the *Act. ventricosus* group as a subgenus, we will have, first, the typical urn-shaped species, such as *S. perumbrosus* and *S. liratus*, with the structure of *Actinocrinites* up to the divisions of the rays, but with the body comparatively long and narrow below, and the secondary and other succeeding supplementary radials, brachial and intermediate pieces, connected laterally all around, and spreading out horizontally far beyond the limits of the body, so as to form, with the flat or much depressed vault, a broad, more or less distinctly ten-angled disc, from the margins of which the numerous long, slender arms arise, without bifurcating after becoming free.† Indeed, with rare exceptions, the rays can scarcely be said to bifurcate, properly, after the division on the third primary radials, though each main division continues on out, throwing off alternately on each side brachial pieces in close contact with each other, until, at last, it terminates in a single free arm. Each of the arms commences abruptly as a double series of small alternating pieces immediately on the last fixed brachial piece, without an intermediate series of free single pieces extending entirely across. Some of the species, such as *S. perumbrosus*, have but a very small simple opening situated subcentrally, or more or less excentrically towards the anal side, and penetrating the flattened vault obliquely, so as to be directed forward or away from the anal side; while others, like *S. liratus*, have a long erect, subcentral tube, or so-called proboscis, sometimes recurved at the end. The column is known, at least in the species provided with a proboscis, to be peculiar in being composed of very thin segments, a part of which, at regular intervals, project out beyond the others, and send up and down, at equal distances all around, five external, thickened processes or ribs, apparently as a natural provision to give it strength, without destroying its flexibility.

Then we have the *Act. ventricosus* group, which not only agrees with the *S. perumbrosus* section of *Strotocrinus* in having merely a very small subcentral or excentric opening in the vault, without any traces of a proboscis, but also, to a considerable extent, in the manner in which the subdivisions of the rays are given off; but differs in having these subdivisions not in contact so as to form a disc, but divided by narrow interradial, anal, axillary, and sometimes interbrachial sinuses, the former of which often extend quite in to the body. The species of this group also differ from the typical forms of *Strotocrinus* in having the body shorter below the arms, and the vault generally more ventricose, and provided with external furrows radiating from the middle to the anal and interradial sinuses. So far as yet known, the species of this type have rather stouter and less numerous arms than we see in *Strotocrinus* proper, but generally more than we see in *Actinocrinites*. In both groups of *Strotocrinus* the arms are, as in *Actinocrinites*, provided with numerous pinnulæ, or so-called tentacles, but here they seem to be always armed with minute spines directed more or less obliquely upward from their upper margins.

From *Actinocrinites* the *A. ventricosus* group not only differs in being without any traces of a proboscis, but in having its ventricose, furrowed vault composed of numerous minute pieces; and the divisions of its rays, although not forming a continuous disc as in *Strotocrinus* proper, not grouped into five lobes. Its arms also differ in never bifurcating after becoming free. For this group we propose the name *Physetocrinus* (φῦσητός, puffed up; κρίνον, a lily, in allusion to the ventricose vault of the typical species, *Act. ventricosus*, Hall.)‡

The genus *Strotocrinus*, as here defined, would include the following species, all peculiar to the lower Carboniferous rocks of America:

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*Second vol. Illinois Report, p. 188, 1866.
† Some of the species have as many as seventy to eighty arms.
‡ Iowa Geological Report, vol. 1, part Palæont., pl. 11, fig. 6, a b.

1.—STROTOCRINUS, M. and W. (proper.)

Section (*a*). Species without a proboscis.—*S. perumbrosus*,* *S. regalis* and *S. glyptus*, all described under *Actinocrinus* by Prof. Hall.

Section (*b*). Species with a proboscis.—*S. ægilops*, *S. rudis*, *S. liratus*, *S. umbrosus*,† *S. tenuiradiatus*, *S. tholus* and *S. insculptus*, all described by Prof. Hall under *Actinocrinus*. It may also probably include his *Act. glans*. His *A. clavis* is believed to be synonymous with his *S. ægilops* (sp.), and his *Act. subumbrosus* a variety of his *S. liratus* (sp.)

2. Subgenus PHYSETOCRINUS, M. and W.

P. ventricosus, *P. cancellatus*, *P. ornatus* and *P. reticulatus*, all described by Prof. Hall under *Actinocrinus;* also *P. subventricosus*, described by Professor McChesney under *Actinocrinus*. The proposed species *senarius*, Hall, is believed to be a variety of his *A. ornatus*.

In the single character of having only a simple opening in the vault, without the slightest indications of a proboscis, the *Physetocrinus* group would agree more nearly with the typical section (a) of *Strotocrinus* than the section (b) does, but in all other characters it is more distinct.

Section (*C*).

STROTOCRINUS ECTYPUS, M. and W.

Body depressed, very rapidly expanding to the third radials, above which the secondary and tertiary radials and brachial pieces curve out horizontally. Base about twice and a half as wide as high, truncated, slightly concave, and not expanded or thickened below, but with small nodes around the margin of the under side, placed one at the termination of each of the costæ. First radial pieces wider than high, two heptagonal and three hexagonal. Second radials one-half to two-thirds as large as the first, wider than high, hexagonal, or in part (sometimes) pentagonal, the superior lateral sides being short. Third radials wider than long, pentagonal, hexagonal, or irregularly heptagonal, and supporting on each superior sloping side a secondary radial, each of which gives origin to brachial pieces leading to an arm on the outer side, and supports on its inner sloping side a tertiary radial, which gives origin to two arms, thus making three arms to each main division, or six to each ray, and thirty to the entire series.

First anal piece a little longer than wide, hexagonal, and supporting two pieces of about half its own size in the next range; between the superior sloping inner sides of these there is one small piece, and above these three or four other small pieces, one or two of which extend up so as to separate slightly the outer brachial pieces of the adjacent rays. Interradial pieces four or five to each area, the upper of which is narrow and extends up so as to separate slightly the brachial pieces above. In each interaxillary space there is usually an elongated intercalated piece, sometimes large enough to truncate slightly the upper margin of the third primary radial, while it continues upward so as to separate the brachial pieces above.

Vault much depressed, and composed of numerous, irregular, slightly convex pieces of moderate size, and provided with a rather stout subcentral proboscis, composed near the base of unequal pieces, some of which are distinctly protuberant.

Surface of all the body plates moderately convex, or sometimes a little angular in the centre, and ornamented with distinct radiating costæ, extending from the middle to the sides of each piece, so as to divide the whole into numerous triangles. These costæ are also more or less compound, so as to form a secondary or (below the middle of the first radials) a tertiary series of smaller, less defined triangles within those formed by the principal costæ.

* See vol. ii, Geological Report Illinois, p. 188, 1866.
† Iowa Report, part II, pl. ii, fig. 3, a b.

Height of body to horizon of arm openings, 0·70 inch; breadth at same, 1·60 inches.

This species resembles in the sculpturing of its body plates *S. glyptus*, Hall (sp.), but has a more depressed body, and is also at once distinguished by having a proboscis, while the *S. glyptus* belongs to the section of the genus with merely a simple opening in the vault. From *S. ægilops* it will readily be distinguished by its shorter, more rapidly expanding body and less numerous arms, as well as by its different sculpturing. Although its brachial pieces are a little separated over the anal, interradial, and axillary spaces, there are no distinct sinuses at these points in the margins of the disc, as the little intercalated pieces separating the brachial pieces at these places extend out as far as the latter, so that when the arms are removed the outline of the disc presents only an obscurely subpentagonal outline.

Locality and position. Lower division Burlington beds of Lower Carboniferous, at Burlington, Iowa. No. 59 of Mr. Wachsmuth's collection.

STROTOCRINUS ? ASPERRIMUS, M. and W.

Body under medium size, urn-shaped, being a little wider at the top of the third radials than high, with the secondary radials and succeeding parts spreading out horizontally, but divided by narrow anal and interradial sinuses quite in to the body; sides ascending with a gradual expansion to the top of the third radials, with a moderately convex outline below the middle. Base about twice and a half as wide as high, not thickened or spreading below, but projecting downward a little around the column, in the form of little nodes, formed by deep notches at the sutures and smaller ones between. First radials generally wider than long. Second radial pieces somewhat smaller than the first, wider than long, some hexagonal and others pentagonal. Third radials a little smaller than the second, generally pentagonal and bearing on each superior sloping side a secondary radial, each of which supports one or more brachial pieces, leading to an arm on its outer sloping side, and a small tertiary radial on its inner, each of which evidently supported two other pieces above, one or both of which were probably brachials. If both sides bore brachials it would make six arms to the ray, but if one side bore an axillary piece it would make eight to the ray or forty in the whole series.

First anal piece of about the same size as the smaller first radials, slightly longer than wide, hexagonal in form, and succeeded by two smaller hexagonal or heptagonal pieces in the second range, above which there seems to be about four other smaller pieces Subradials three or four to an area, the first one about as large as the second radials, hexagonal or heptagonal in form, and supporting two smaller pieces in the next range; above this there seems to be one, or possibly sometimes two other smaller pieces. Axillary spaces sometimes occupied by one or two small pieces.

Vault much depressed, or rising little above the horizon of the arms, composed of irregular small and moderate sized pieces, and provided with a nearly central proboscis, which in the typical specimen is composed of very small pieces at the base, and a little inclined to one side.

Surface of body plates all prominent and angular in the middle, and provided with well defined, sharp radiating costæ, which are compound on the first radial and first anal pieces, but generally consist of a single rib, extending from the middle to each of the sides of the others. The mesial prominence on each of the first and second radials is pinched out so as to form a prominent sharp, transversely arranged ridge, while on each of the smaller plates it is a rounded, rather pointed node, the whole presenting a very rough appearance.

Height of body to the horizon of the arms, 0·74 inch; do. to top of vault, 0·88 inch; greatest breadth at the top of third radials, 0·80 inch.

In general form and surface markings this species resembles the following,

but its body is more spreading above and it has ten or more arms less, while its vault is much more depressed and provided with a proboscis. It seems to bear much the same relations to the section (b) of the genus *Strotocrinus* that the subgenus *Physetocrinus* bears to the typical forms of *Strotocrinus*.

Locality and position. Burlington Limestone of the Lower Carboniferous at Quincy, Illinois.

Subgenus PHYSETOCRINUS, M. and W.

STROTOCRINUS (PHYSETOCRINUS?) ASPER, M. and W.

Body somewhat urn-shaped, being obconical below, with nearly straight, gradually expanding sides, and rather ventricose vault. Base about three times as wide as high, truncated below and angular, though not thickened or properly expanded around the lower margin, which is so broadly and deeply notched at the sutures as to present a trilobate appearance as seen from beneath. First radials wider than high, and as usual two heptagonal and three hexagonal. Third radials of the same size as the second, and bearing on each of their superior sloping sides a somewhat smaller secondary radial, each of which bears on its outer sloping side a series of brachial pieces, leading to an arm, while on its inner sloping side it supports a small tertiary radial, bearing on its inner side brachial pieces leading to an arm, and on its outer a small quaternary radial, bearing on its outer side a brachial piece, and on its inner another axillary piece, giving origin to two arms, thus making, as far as can be determined, ten arms to each ray, or fifty to the entire series.

First anal piece as long as the first radials, but narrower, heptagonal in form, and supporting one small piece over its middle and a larger one on each upper sloping side in the second range; in the third range there are three, in the fourth two pieces, and above these, three smaller pieces extending up so as to connect with the vault. First interradial pieces of about the size of the third radials, hexagonal in form, and bearing two smaller pieces in the second range, above which there are some five or six very small, irregular pieces, some of the upper of which extend up and connect with the vault.

Vault rather ventricose, or more than one-third as high, near the middle, as the body below the horizon of the arms; composed of irregular nearly flat pieces of moderate size; opening apparently simple, at the highest point about one-third of the distance from the middle towards the posterior side.

All the body plates are protuberant and sharply angular in the middle, the angular part, especially on the larger plates, forming a sharp transverse ridge. From the under side of this transverse ridge two or three others extend downward on the first radial and first anal pieces, so as to connect with others on the basal pieces. The second and third radial pieces have each about three small pointed nodes, arranged transversely, while from the third radials narrow ridges extend up to the secondary radials, thence up all the branches to each arm base. All the smaller body plates also have a more or less projecting angular point in the middle.

Notwithstanding the number of arms, the narrow anal and interradial sinuses extend in so as to divide the disc quite in to the body, while even the interbrachial sinuses extend nearly in to the body. The column is of moderate thickness near the base, where it is round and composed of thin pieces with sharp projecting edges, pierced by a nearly round central canal.

Height to horizon of arms, 0·73 inch; breadth across at the interradial sinuses, 0·90 inch; height of vault, 0·46 inch.

This species has its plates sculptured in nearly the same way, and presenting much the same roughened appearance seen in *S. glyptus*, Hall (sp.), but it differs materially from that and all of the other species known to us, that resemble it in other respects, in having deep interradial and anal sinuses in its disc, as in the subgenus *Physetocrinus*, with which it also appears to agree in its ventricose vault. It is the only species known to us, however, appa-

rently belonging to that group, that has its body so narrow and produced below, and its body plates presenting the style of angularly sculpturing. If the interradial and anal sinuses of its disc were filled with intercalated pieces it would present nearly all the characters of a typical *Strotocrinus*. Consequently it may be regarded as a connecting link between these groups, and with a few others shows that they cannot be properly separated more than subgenerically.

Locality and position. Upper beds Burlington group of Lower Carboniferous, at Burlington, Iowa. No. 67 of Mr. Waehsmuth's collection.

STROTOCRINUS (PHYSETOCRINUS) DILATATUS, M. and W.

Body rapidly expanding, with nearly straight sides, from the base to the secondary radials, thence spreading more abruptly to the brachial pieces, which are directed out nearly horizontally, and so closely crowded all around as to come very nearly, or sometimes quite, in contact over the anal and interradial areas. Base about three times as wide as high, not thickened or expanded below, but provided with a large round perforation. First radial pieces comparatively large, generally wider than high, two heptagonal and three hexagonal. Second radials only about half as large as the first, some of them quadrangular, and others with one or both of the upper lateral angles a little truncated, so as to make them properly pentagonal or hexagonal. Third radials larger than the second, wider than long, pentagonal, hexagonal or heptagonal, and supporting on each superior sloping side a secondary radial, each of which gives origin on its outer side to brachial pieces leading to an arm, while on its inner side a tertiary radial gives origin to two arms in all but the two posterior rays, where one or sometimes both bear on one side another axillary piece, making seven or eight arms in each of these rays, or, in the latter cases, thirty-four arms to the entire series.

First anal piece as large as the largest first radial pieces, and bearing above two heptagonal or octagonal pieces of near its own size in the second range, with three smaller pieces in the third range, and two or three minute pieces over these, one of which is wedged in between the brachial pieces above. First interradial pieces generally larger than the second radials, heptagonal or octagonal, and surmounted by two smaller pieces in the second range, over which we usually see one or two small pieces wedged up between the outer brachial pieces of the rays on each side. There is also usually a small interaxillary piece between the secondary radials of each ray, but it seems never large enough to extend down so far as to truncate the upper angle of any of the third primary radials.

Arms stout, increasing a little upward for a distance of two and a half inches (as far as they can be seen in the specimen), each passing directly into a double series of very short pieces, from their origin on the last brachial piece.

Surface of body plates merely finely granular where not worn, slightly convex, with shallow indentations at their corners. Vault unknown.

Height of body to the top of tertiary radials, 0·75 inch; breadth, about 1·33 inch; breadth of arms two inches above their bases, 0·20 inch.

This species is related to *S.* (*Physetocr.*) *subventricosus*, McChesney (sp.), but differs in having its body much more rapidly expanding, and proportionally wider above, while its tertiary and brachial pieces curve much more strongly outward. It also differs in the relative size and form of its second radial pieces, which are proportionally smaller, and generally quadrangular, or only with the upper lateral angles slightly truncated, instead of being larger and regularly hexagonal. Its arms are likewise stouter than those of McChesney's species, judging from the brachial pieces seen in specimens of the latter, while it has one or two arms more in each of the posterior rays. Its surface markings are also different, but this is a very variable character in this group.

Locality and position. Lower beds of the Burlington group. Lower Carboniferous. No. 58 of Mr. Wachsmuth's collection.

Genus MEGISTOCRINUS, O. and S., 1850.

The type upon which this genus was founded (*M. Evansii*, O. and S.*) has a short, broad, cup shaped body, with a depressed vault, and sides moderately expanded above, and rounded under below to the flat anchylosed base, which is usually a little impressed, or less prominent than the first radial and first anal pieces extending horizontally outward all around it so as to form a part of the under side. In some species the base is not properly impressed, though it can rarely be said to project beyond the surrounding next range of pieces. The body plates are moderately thick, and separated by well defined, or rather deep sutures, so as to present a more or less convex surface, without sculpturing or radiating costæ, though there are rarely small indentations at the corners of some of the plates.

The nearly or quite flat vault is composed of unequal, irregular, more or less tumid or convex pieces, of moderate size, the middle one sometimes rising into a prominent, rather pointed node, that may be, in some cases, even developed into a short spine. The opening is decidedly lateral, often penetrating the anal side *below* the horizon of the arm bases; sometimes it is on the same horizon as the arm openings, or rarely slightly above them. It is never situated in a thickened protuberance, however, as in *Dorycrinus* and *Agaricocrinus*, but always shows thin, broken, abruptly projecting edges, as if, when entire, it had been produced into a short, slender tube, or so-called proboscis, projecting out horizontally backward.

In the number and arrangement of the pieces composing the walls of the body, up to the third radial pieces inclusive, this genus presents no essential differences from *Actinocrinus*, with which it also agrees in having the arm bases more or less grouped, or separated by interradial and anal spaces, and never forming a continuous series all around, as in *Batocrinus*,† nor an expanded disc, as in *Strotocrinus*. It not only differs from *Actinocrinus* proper, however, in general physiognomy and the nature and position of the opening, but particularly in having its arms each composed of a double series of alternating pieces *below all the bifurcations*, as in *Amphoracrinus*, from which, however, it differs widely in other respects. This peculiarity of having the arms each composed of a double series of alternating pieces *below* as well as above the bifurcations, is not only continued down *to* the body, but in some species each division of the rays included as a part of the walls of the body, has the same structure nearly one-fourth of the way down the side, to within one or two pieces of the third primary radials.

The six or seven known true typical species of this genus form so natural a group that they can be readily distinguished at a glance from the allied genera such as *Amphoracrinus*, *Agaricocrinus*, *Dorycrinus*, *Cœlocrinus*, *Strotocrinus*, &c. There is, however, at least one, and probably two, known Carboniferous species, standing as it were between *Megistocrinus* and *Saccocrinus*, and combining the characters of both to such an extent that one of them (*Act.* (*Megist.*) *Whitei*, Hall) was referred by Prof. Hall to *Megistocrinus* (which he seems to regard as a section or subgenus of *Actinocrinns*), while the name of the other was written by us, *Actinocrinus* (*Saccocrinus ?*) *amplus*,‡ because we were con-

* Owen's Geol. Report, Wisconsin, Iowa and Minnesota, pl. V, A, fig. 3.

† We cannot believe that those remarkable truncated forms, with arm bases in contact all around, and an erect subcentral proboscis, such as *M. spinosus*, of Lyon (Proc. Philad. Acad. N. S. Decr. 1861, pl. iv, fig. 7), really belong to *Megistocrinus*.

‡ It is possible, as already intimated, that this may not be distinct from Prof. Hall's species *Whitei*; but as it is larger and more robust, however, and has its body plates more convex, and without the ridge seen extending up the radial series of the species *Whitei*, which also differs in some other details, and came from the upper part of the Burlington beds, and ours from the lower, while scarcely any species of Crinoids are believed to be common

vinced that it is not a *true Actinocrinus*, and believed it related to *Saccocrinus*. From direct comparisons with Prof. Hall's typical specimens of the species *M. Whitei*, in the Museum of the University of Michigan, Professors Winchell and Marcy were also led to refer Silurian species of *Saccocrinus* to *Megistocrinus*.

The Silurian typical forms of *Saccocriuus* have the same arm structure, as well as essentially the same arrangement of body plates, as *Megistocrinus*, but differ in having a much more elongated narrow body, composed of thin even plates (without excavated sutures) and a protuberant obconic, instead of a flat or impressed base, also a subcentral opening (or proboscis?) instead of a decidedly lateral proboscidiform opening in the vault, thus presenting a decidedly different general physiognomy from the typical Carboniferous forms of *Megistocrinus*. If we had only the typical forms of these two groups to deal with, there would be no difficulty in separating them. The two species, or varieties, *Whitei* and *amplus*, however, are not so easily disposed of, since they have the same thin smooth plates, without impressed sutures, seen in *Saccocrinus*, and nearly as protuberant a base, while their body is exactly intermediate in form,* and their arm structure the same as in both of these groups, with which they also equally agree in the number and arrangement of the body plates. We have never seen a specimen of any of the Silurian species of *Saccocrinus* showing the vault, but all the casts we have examined seem to show that it was nearly flat, and had either a subcentral opening or proboscis, and no traces of a decidedly lateral opening as in typical forms of *Megistocrinus*. A specimen figured by Dr. Roemer in his work on the Silurian fossils of Tennessee, shows the vault to be protuberant in the middle and provided with an opening there, with some appearance of being surrounded by the remains of the base of a proboscis, though it may possibly be only a simple opening in a prominence. In the Carboniferous species *Whitei*, as already stated, there is a small subcentral opening in the depressed vault, without any traces of a proboscis, and we can now scarcely doubt that this is the case with the *amplus*, and the vault of both these species also differs from that of the typical *Megistocrinus* in being composed of innumerable minute pieces.

Although there are a few points in regard to the relations between these groups that we have not yet been able entirely to clear up, we are, from all the facts now known to us, inclined to believe that *Saccocrinus* should be ranged as a subgenus under *Megistocrinus*. At any rate, if the species *Whitei* and *amplus* are to be included under *Megistocrinus* at all, we think they should certainly be at least placed in a separate subgenus from the typical forms, and until these questions can be more definitely settled from the study of more extensive collections we prefer to retain for this subgenus the name *Saccocrinus*. With these limits the genus *Megistocrinus* would include the following American Carboniferous forms:

1. MEGISTOCRINUS, Owen and Shumard, 1850.

Body short, broad and composed of rather thick convex pieces; base flat,

to these two horizons, we are not entirely convinced that they are identical. All the specimens of the species, or variety, *amplus* we have seen are in a more or less crushed condition, which in some instances caused the vault to protrude in such a way as to lead us to believe it provided with a central or subcentral proboscis, especially as several of the specimens clearly show that it certainly has no traces of a lateral opening anywhere near the anal side, as in the typical forms of *Megistocrinus*. Mr. Wachsmuth informs us, however, that he has recently found a specimen of the species *Whitei* showing that it has a small subcentral simple opening, much as in *Strotocrinus*, section (a), and from the close relations of our *amplus* to that species, it is highly probable that it also has a similar opening, without a proboscis.

* It is proper that we should also state here that there are considerable differences of form among the Silurian species of *Saccocrinus*; for instance, we have now before us, from the Niagara beds of Chicago, rude natural casts, having all the characters apparently of undescribed species of this group, that are as short and broad as even the typical Carboniferous forms of *Megistocrinus*; while specimens of *Saccocrinus Christyi*, Hall, now before us, from the Niagara beds of Waldron, Indiana, have the body presenting almost exactly the form of the typical specimens of the Carboniferous species *Whitei*, with which, through the politeness of Prof. Winchell, we have been able to compare them.

impressed, or scarcely more prominent than the first anal and first radial pieces; vault composed of moderate sized convex pieces; opening decidedly lateral, produced in the form of a small short proboscis? and directed posteriorly.*

Megistocrinus Evansii, Owen and Shumard; *M. plenus*, *M. crassus*, White; and *M. brevicornis* and *M. superlatus*, described by Prof. Hall under *Actinocrinus*.† Also our *M. parvirostris* of this paper. All of which are from the Lower Carboniferous.

? 2. Subgenus SACCOCRINUS, Hall, 1852.

Body usually more elongated, with a protuberant base; body plates thin, even, or not convex; vault composed of small or minute pieces, and provided with a small subcentral simple opening, or possibly sometimes with a proboscis.

Actinocrinus (*Megistocrinus*) *Whitei*, Hall, and *Act.* (*Saccocrinus*?) *amplus*, M. and W.

MEGISTOCRINUS PARVIROSTRIS, M. and W.

Body rather small, of the usual short cup shape, about one-fourth wider than high. Base nearly even with the surrounding first radial and first anal pieces. First radials near one-third wider than long. Second radials a little smaller than the first, hexagonal in form. Third radials as wide as the first, but shorter, pentagonal or hexagonal, and each supporting on each superior sloping side two brachial pieces in direct succession, upon the last of which rest two or three series of double alternating pieces before the commencement of the free arms, making two arm openings to each ray, or ten to the entire series. First anal piece wider and a little shorter than the first radials, supporting three smaller pieces in the next range, above which there are four or five in the third, and five in the fourth ranges, which latter connect with numerous very small pieces forming and surrounding the little short proboscidiform opening. First interradials about as large as the second radials, and bearing two smaller pieces in the second range, three in the third and two or three in the fourth, with a few minute pieces in the latter.

Vault a little convex, composed of moderate sized, convex or tuberculiform pieces, the largest and most prominent of which is in the middle, and the others surrounding it, while a few minute pieces are intercalated between and around the latter, particularly on the anal side. Anal opening in a short, little proboscidiform protuberance, placed entirely below the horizon of the arm bases, and directed a little obliquely downward. Body plates, excepting the small ones, connected with the opening, all rather tumid, and separated by excavated sutures, somewhat indented at the corners of the plates. Arms and column unknown.

Height of body to top of central node of the vault, 0·80 inch; breadth, 0·96 inch; height to arm openings, 0·58 inch; do. to anal opening, 0·38 inch.

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* This diagnosis is not intended as a full description of the genus, but merely to give the characters distinguishing the typical section of the genus. If such Devonian species as *M. lutus*, Hall, and *Actinocrinus abnormis*, Lyon, belong to this genus, they could not be properly included in the typical section with the Carboniferous species. They have the broad depressed form of *Megistocrinus* proper, but differ in having thin even body plates, without impressed sutures, and the first, at least, in having a subcentral opening in the vault, while the plates of the species *abnormis* are, when well preserved, ornamented, even on the vault, with delicate radiating striæ. From the appearance of its arm bases, in the specimens we have seen, they would seem to have also been constructed differently from those of the Carboniferous species, while the arm openings present the curious character of being each divided by a transverse horizontal septum into two distinct openings, one directly over the other. The anal opening in this species, however, is lateral, and much like that of the typical *Megistocrinus*. In each of the four specimens of this species we have seen, from the original locality, there are only the usual five series of radials (three each) instead of six, as in that from which Mr. Lyon's description was drawn up.

† *Act. minor*, Hall, is believed to be the same as his *A. brevicornis*.

This species is apparently most nearly allied to *M. brevicornis*, Hall (sp.), but differs in having a greater number of ranges of brachial pieces included as a part of the walls of the body, and these pieces wider and commencing as double series farther down. Its opening is also placed decidedly lower even than the proposed species *Act. minor*, of Hall, being distinctly below the horizon of the lower edge of the arm openings, and nearly halfway down the side, measuring from the highest part of the vault. Its larger vault pieces, excepting the middle ones, are also more prominent and pointed. Its body and vault plates are all much more convex, its arm bases stouter, its vault less depressed, and its opening decidedly lower than in *M. superlatus*, Hall (sp.).

Locality and position. Upper Burlington beds of the Lower Carboniferous at Burlington, Iowa. No. 161 of Mr. Wachsmuth's collection.

Genus DORYCRINUS, Roemer.

Dorycrinus canaliculatus, M. and W.

Body under medium size, cup-shaped below the arms, rather rapidly expanding from the lower margins of the first radials to the arm bases. Base extremely short, its entire height merely consisting of the thickness of the plates, subhexagonal in outline, with small lateral notches at the sutures, scarcely projecting below the first radial and first anal piece; facet for the attachment of the column occupying about half the breadth of the base, round and rather deeply impressed. First radial plates about once and a half as wide as high, all very nearly hexagonal, there being scarcely any perceptible angle at the middle of those over the sutures of the base. Second radials scarcely half as large as the first, about once and a half as wide as long, and presenting the usual quadrangular outline. Third radials a little wider and shorter than the second, pentagonal in form, and bearing on their upper sloping sides, in the posterior rays, two slightly smaller secondary radials, each of which supports two brachial pieces, thus giving origin to four arm openings to each of these two rays; while in the anterior ray one side of the third radial merely bears a series of branchial pieces leading to an arm, and its other side a tertiary radial, supporting two brachial pieces, thus making three arms to this ray. In both anterior lateral rays each third radial bears on each side two brachial pieces in direct succession, making only two arm openings to each of these rays, or fifteen to the entire series.*

Anal pieces about eight, below the horizon of the arm openings; first one as wide as the first radials, and a little longer, heptagonal in form, and bearing three smaller pieces in the second range, above which there are five smaller pieces in the third range, connecting with others extending up to the opening of the vault. First interradials nearly half as large as the first radials, heptagonal in form, and bearing two smaller pieces in the second range, above which one or two small pieces intervene to separate the brachial pieces, and connect with the vault.

Vault about two-thirds as high above the arm openings as the height of the body below, provided with a single rather pointed and prominent central node that may be in some instances developed into a short spine. Opening with margins a little projecting and situated in a slightly impressed area above the horizon of the arm openings.

Body plates convex, separated by deeply canaliculated sutures, and roughened by a peculiar shallow pitting over the entire surface, but which is larger and deeper at the edges of the larger plates, to which it imparts a slightly crenate appearance. The plates of the vault are also defined by the same deeply canaliculate sutures, and roughened by similar pitting to that on the body plates, though they are not convex like the latter.

As we have not seen the arms of this species it is barely possible that it may

* Sixteen is probably the *normal* number.

be more properly an aberrant *Agaricocrinus* than a true *Dorycrinus*. Its arm bases, however, or rather the brachial pieces, have not the breadth and stoutness seen even in the most aberrant species of the former group, such as *Agar. corniculus* (= *Act. corniculus*, Hall), and from their appearance there is little room for doubting that it had two slender arms from each arm opening, instead of a single stout one as in *Agaricocrinus*, which, so far as we are aware, never has more than three arm openings to each posterior ray and two or three to each of the others. It is the only species we have ever seen of the *Dorycrinus* group with the peculiar sculpturing of its body plates already mentioned. This sculpturing, however, is very different from that seen on *Agaricocrinus corniculus*, which the species most nearly resembles in several respects, being a peculiar pitting of the whole surface of each individual plate, with a few larger marginal indentations. Its greater number of arm openings (four to each posterior ray, and three to the anterior one, instead of two to each all around) would alone at once distinguish it from that species, even in specimens without the arms.

Locality and position. Lower bed of Burlington Limestone, Burlington, Iowa. Lower Carboniferous. No. 150 of Mr. Wachsmuth's collection.

Genus AGARICOCRINUS, Troost.

AGARICOCRINUS NODOSUS, M. and W.

Body, without the arms, having a truncato-suborbicular general outline, being convex above and broadly truncated below; under side moderately concave out to the second radial pieces inclusive. Base small, impressed deeper than the general concavity of the under side, and entirely hidden by the column. First radial pieces extending out horizontally from the end of the column, and exposing a flat hexagonal surface nearly twice as wide as long. Second radials nearly as large as the first, a little wider than long, and presenting the usual quadrangular form. Third radials tumid, or projecting distinctly beyond the surface of the second and first; wider than long, larger than the second, and pentagonal or hexagonal in form; each bearing on its outer sloping sides two series of tumid, stout alternating brachial pieces, directed horizontally outward, and in all but the two posterior rays, forming the base of two stout arms. In the posterior rays, intermediate brachial pieces are intercalated between the others so as to give origin in each of these rays to three arms, thus making twelve arms to the entire series.

First anal piece about as wide as long, heptagonal in form, with a flat surface entirely included within the concavity of the under side, supporting in the next range three pieces, which are longer than wide, and curve up so as to form a part of the outer wall, but are not included within the concavity of the under surface. Of these the lateral two have a general oval outline, with eight or nine sides and a tumid surface, while the middle one is hexagonal, moderately convex, and much narrower at the inner than the outer end. Above these are three other smaller pieces, connecting with the vault. First interradial pieces about once and a half as long as wide, with nine sides, the inner half being flat and included within the concavity of the lower side, and the outer tumid. Connecting with the outer end of each of these are two elongated narrow pieces in the second range, which are usually tumid at the lower end, and extend up between the brachial pieces, to connect with the vault. Arms unknown.

Vault composed of irregular, unequal, tumid larger and smaller pieces. Of the larger, more prominent pieces, one is situated over each ray, and another at the middle; while a series of four or five somewhat smaller pieces immediately surround the anterior and lateral margins of the middle one. The intermediate spaces are occupied by much smaller and less prominent pieces. Opening nearly over the posterior side and penetrating a very prominent thickened ridge, which extends from the middle to the anal side, and is composed of comparatively large pieces for this part.

Surface of all the plates, including those of the vault, regularly granular. Column of moderate size, round, and composed near the base of alternately thicker and thinner pieces, with radiately striated surfaces, and perforated by a very small nearly rounded central canal.

Height of body to top of vault, 0·88 inch; breadth, including three brachial pieces on each side, 1·13 inches; breadth of concavity of under side, 0·57 inch; thickness of column 0·40 inch from base, 0·17inch.

This species differs from all the others yet known from the Burlington group, in having three arms to each posterior ray. It is most nearly allied to *A. bullatus*, Hall, a single individual of which, out of a considerable number in Mr. Wachsmuth's collection, has abnormally three arms in *one* of the posterior rays all the others having two to each ray all around. It differs also from all of these, however, as well as from the original type now before us, in having the concavity of the under side less deep, and all the pieces surrounding it more tumid, while the form and proportions of its body pieces are different, its anal region much more protuberant, and its vault pieces less rounded and swelled. Its surface is also more coarsely granular.

Locality and position. Highest part of the upper bed of the Burlington group at Burlington, Iowa. Lower Carboniferous. No. 146 of Mr. Wachsmuth's collection.

Genus PLATYCRINITES, Miller.

Platycrinites tenuibrachiatus, M. and W.

Body rather small, subglobose, being somewhat wider than high. Base shallow, or dish shaped, with a subpentagonal outline and a rather broad shallow concavity below, nearly twice as wide as the rather small round facet for the attachment of the column. First radial pieces a little wider than high, having a general quadrangular form, but with the superior lateral angles slightly truncated for the reception of the interradial pieces, and the lower sides a little convex in outline; sinus in the upper side of each equaling about half its breadth, and extending down on the outer side about one-third to one-fourth its length. Sutures channeled by the beveling of the edges of the plates. Second radial pieces very small, wider than long, triagonal in form, and wedging out on each side so as to allow the first brachial pieces to come in contact with the first radials at the lateral edges of the sinuses in the same.

First divisions of the rays, from their origin on the second radial pieces, each round and composed of a single series of somewhat wedge shaped pieces to the fourth piece, which has a pentagonal outline and gives origin to two divisions, the inner one of which is smaller than the other and without farther bifurcations, being a simple arm, composed below, for some little distance, of a single series of wedge formed pieces, beyond which it passes gradually into a double series of alternating pieces, while the outer division bifurcates on the second piece, its outer subdivision remaining simple like the inner of the first divisions, already described, and its inner division bifurcates again on the fourth pieces, forming two arms like the others, thus making four arms to each of the two main divisions of each ray, or forty arms to the entire series, all of which are long, slender, and without spines or other asperities. Pinnulæ, or so-called tentacles, slender, rather crowded, and composed of joints that are longer than wide and deeply furrowed within.

Surface of body plates marked with small rough ridges, which on the first radial pieces run parallel to the lower and lateral margins, with more or less irregularly disposed granules on the central region, sometimes showing a tendency to radiate from the sinuses for the second radial pieces.

Height of body, 0·30 inch; breadth of same, 0·50 inch; length of arms, measuring from the first divisions on the second primary radials, about 1·50 inch, do. to first bifurcation above, 0·22 inch; breadth of each individual arm above all the bifurcations, 0·05 inch.

This species is related to *Platycrinus Americanus*, of Owen and Shumard, with which it agrees in the size and form of its body. Its surface sculpturing, however, is somewhat different, that species having merely a nodular ridge running along the lower and lateral margins of the first radial plates, and two others starting from the lower lateral angles and converging to the sinuses in the middle of the upper edge, with little isolated nodes on the intermediate spaces; while in the species under consideration there are merely three somewhat nodular ridges, parallel to the basal and lateral margins of these plates, with more or less granules in the central region. As such markings, however, are subject to some variation in individuals of the same species of this group, we should not have regarded the differences mentioned of sufficient importance to warrant the establishment of another species, if it were not for the additional fact that Mr. Wachsmuth finds specimens agreeing exactly with Owen and Shumard's species in the ornamentation of the body, and yet having only six arms to each ray, or thirty in the entire series, instead of eight to each ray, as in that under consideration.

P. Wortheni, Hall, agrees with this in having eight arms to the ray, but they are much stouter, and differ in being roughened by numerous small asperities, while its second radial pieces are much smaller, and each supports on each side above only two very short pieces between it and the first bifurcations above, instead of four. Similar differences are also seen in the details of the other divisions, while the surface ornamentation of the two species is entirely different, and the base of the *Wortheni* is flat or broadly concave, instead of being moderately convex with merely a central concavity.

Locality and position. Upper beds of Burlington Limestone, Burlington, Iowa. No. 218 of Mr. Wachsmuth's collection.

Genus PROTASTER, Forbes.

PROTASTER? GREGARIUS, M. and W.

The disc of this species is circular in outline, slightly convex above, and measures from 0·20 to 0·30 inch in diameter. In most cases it looks as if merely covered by a smooth membranaceous integument. Some casts of its external surface, however, seem to show traces of flat, nearly smooth, imbricating scales above. The five arms are slender, flexible, and rather long in proportion to breadth. In a specimen with a disc measuring 0·25 inch in breadth, the diameter of the arms near the disc is only 0·05 inch. None of the specimens show the entire length of the arms, though some fragments of them were seen lying detached in the matrix, about 0·55 inch in length, without being complete at either end. From the breadth and gradual taper of these it would seem probable that when entire they may have been 0·75 to 1 inch in length. Their impressions in the matrix give no indications of a longitudinal furrow along the under side, but show that there were about six pairs of arm pieces in a length of 0·16 inch. These pieces appear to be nearly though not exactly opposite, and each one provided below with a comparatively large, round, deep pit or pore, near the middle of its anterior side. Along their lateral margins there appear to be impressions in the matrix of very small spines (one to each arm piece), though if such they must have been extremely short. Impressions of the upper side of the slender arms show them to have been somewhat rounded above, with the nearly square arm pieces slightly alternating. Some of the impressions seem to show traces of central pores or pits, one at the middle of each pair of pieces, though in others no traces of these are visible.

We have numerous specimens of this little species before us, but as they are all merely in the condition of casts and moulds in a very fine, somewhat granular matrix, they do not show the details of its structure very clearly. As far as its structure can be made out, however, it seems to agree well with the general features of the genus *Protaster*, as illustrated by Prof. Hall in the Twentieth Report of the Regents of the University of N. Y. on the State Cabi-

net of Nat. Hist., though not with Mr. Salter's figures of *P. Miltoni*. It will probably be found to be generically distinct from the Silurian typical forms of *Protaster*, but we prefer to place it provisionally in that genus for the present. We are not aware that any well defined species of the genus *Protaster*, however, have been found in Carboniferous rocks.

Locality and position. Crawfordsville, Indiana. Keokuk division of the Lower Carboniferous series.

MOLLUSCA.

Genus CHÆNOCARDIA, M. and W.

(χαίνω, to gape; καρδία, the heart; in allusion to its gaping front and general form).

Shell equivalve? rather thin, very inequilateral, more or less oval, beaks small, depressed and nearly terminal; valves strongly gaping in front, and closed behind; hinge unknown, but short and without cardinal area; surface with concentric striæ, crossed on the posterior dorsal region by faintly marked radiating costæ, and on the gaping front by radiating lines and costæ.

Although we have not seen the hinge of this type and know very little of its muscular* and pallial impressions, it differs so decidedly in its external characters from all the established genera known to us, that we cannot doubt the propriety of proposing a new genus for its reception. In the single character of having the valves distinctly gaping anteriorly, it resembles the Silurian genus *Hippomya* of Salter, to which it may bear some relations. It differs, however, in having the gaping part of the valves terminal, instead of occupying the anterior ventral region. When placed with the hinge line in a horizontal position, the margins of the gaping part (which are not thickened and reflected as in Mr. Salter's genus), are found to slope slightly forward, as if truncated, in that direction from immediately in front of the beaks, instead of sloping posteriorly to the middle of the basal margin. Our type also differs in the possession of radiating markings, and much smaller umbones, as well as in being less gibbous. It is true that some of these characters might be merely specific, but we cannot believe they all are; while the general physiognomy of the two forms is so different as strongly to impress the mind with the idea of their belonging to entirely distinct genera.

Without a knowledge of its hinge and interior, it is not possible to arrive at very satisfactory conclusions in regard to the family relations of this shell, though we are inclined to believe it related to the *Mytilidæ*. The gape of the front was doubtless for the passage of a byssus, as it is too high up from the antero-ventral margin to have been for the protrusion of a foot to be used in crawling about.

The description is made out from left valves only.

CHÆNOCARDIA OVATA, M. and W.

Shell obliquely ovate, more than two-thirds as wide as long, moderately gibbous, the greatest convexity being a little in front of the middle. Posterior outline rounding into the cardinal margin above, and into the base with a broad subsemicircular curve; deepest part of the base behind the middle, from near which the anterior ventral margin ascends very abruptly and a little obliquely forward, with a slightly convex outline, to the lower part of the anterior hiatus. Anterior gaping edge truncated, with a slightly convex outline and forward slope from immediately in front of the beaks, and defined, or separated from the body of the shell by a faint sulcus, starting from the immediate front of the beak, and curving downward so as to intersect the margin at the base of the hiatus, which (supposing it to be equally developed in the

* One internal cast appears to show trace of a long narrow, anterior adductor muscular scar near the edge of the gaping part of the valve.

right valve) is about twice as long as wide, and of a broad lance-ovate form, most angular at the base. Hinge line scarcely more than one-fourth the greatest length of the shell, measuring obliquely from the anterior extremity to the posterior basal margin, and ranging at an angle of about 45° to the longer axis of the valves. Beaks very small, incurved, and depressed almost to the cardinal margin ; located nearly over the anterior edge. Surface with concentric striæ obscure ; radiating costæ of the posterior dorsal region very faintly marked, and broader than the slight furrows between, while very obscure traces of fine longitudinal striæ may be seen on some of them ; radiating costæ of the anterior, fine, and rather sharply defined on the gaping edge, back of which a few larger obscure ribs may be seen, the posterior one of which is larger than the others, and curves down from the anterior side of the beak so as to intersect the margin of the valve a little below the lower end of the hiatus.

Length, 2 inches ; height, measuring at right angles to the greatest length, 1·48 inch ; convexity of the left valve, 0·50 inch ; length of anterior hiatus, 0·63 inch ; breadth of do. in same, 0·16 inch.

This shell differs so widely from all others known to us from our Carboniferous rocks, that a comparison is unnecessary. Indeed we know of no other form liable to be confounded with it, from rocks of any age.

Locality and position.—West Pecan Creek, Grundy County, from the lower part of the Coal Measures.

Genus ALLORISMA, King.

ALLORISMA COSTATA, M. and W.

Shell under medium size, longitudinally oblong, the length being more than twice the height, very thin, rather convex in the central and umbonal regions ; anterior margin rather short, closed and narrowly rounded ; basal margin forming a long nearly semi-elliptic curve, with a very slight sinuosity in front of the middle ; posterior side compressed ; but apparently a little gaping and distinctly truncated, nearly vertically, from the base about half way up, and thence a little obliquely forward and upward to the dorsal margin ; posterior dorsal region compressed above the unbonal ridge ; cardinal margin equaling about two-thirds the entire length of the shell, very nearly straight, and inflected so as to form a narrow or lance-linear corselet, extending its whole length; beaks convex, rising a little above the cardinal margin, and placed slightly more than one-sixth the length of the valves behind the anterior extremity ; lunule well defined and lance-ovate in form. Surface ornamented by about twenty-five very regularly arranged, distinctly elevated concentric costæ, which commence near the lunule, and extend backward parallel to the base, to the well defined, angular umbonal ridge, leading from the beaks to the posterior basal extremity, at which ridge they become suddenly obsolete, or very nearly so, being mainly represented on the more compress posterior dorsal region by distinct lines of growth, which are crossed on the middle of this area by a second oblique linear ridge extending from the beaks to the middle of the posterior margin. Some indications of the usual minute surface granules appear to be visible in some of the moulds left in the matrix.

Length, about 1·20 inch ; height, 0·53 inch ; convexity, 0·44 inch.

This is a very neat, elegant species, of the type *A. elegans*, King, and *A. Geinitzii*, Meek, (=*E. elegans*, Geinitz,* not King). It is a more slender species, however, with much more sharply elevated, and more regularly disposed costæ than the former ; while it will also be readily distinguished from the latter by its costæ, and much more depressed umbones, wider (higher) posterior extremity, &c. The regularity and prominence of its concentric costæ, and their very abrupt termination along the umbonal ridge or carina, are remarkable

*Carbon f. und Dyas in Nebraska.

characters that give the posterior half of the valves much the appearance of some types of Trigonia.

Locality and position.—Found by Mr. Green, of the Illinois Survey, in Warren County, Illinois, in a black bituminous limestone near the base of the Coal-measure, associated with *Lima retifera*, and *Cardiomorpha Missouriensis*, Shumard, *Aviculopecten ? carbonarius*, Stevens, sp., (=*Pecten Broadheadii*, Swallow, = *P. Hawni*, Gein.), *Spiriferina Kentuckensis*, Shumard, *Chonetus mesoloba*, N. & P., *Schizodus curtus*, M. & W., and various other species, many of which have been generally, until recently, supposed to be mainly confined to the upper part of the Coal-measures.* Mr. Broadhead also found it associated with many of the same fossils near the upper part of the Coal-measures in Fayette county, Illinois.

August 3d.

The President, DR. HAYS, in the Chair.

Twelve members present.

August 10th.

The President, DR. HAYS, in the Chair.

Eighteen members present.

August 17th.

The President, DR. HAYS, in the Chair.

Sixteen members present.

On motion, it was resolved, that the Academy take part in the Centennial Anniversary of Humboldt's Birthday, to be held on the 13th and 14th of September. Dr. H. C. Wood, Jr., was appointed by the Academy as orator, to deliver an address on the occasion.

The following paper was offered for publication: "On Brevoortia," by Alphonzo Wood.

August 31st.

DR. MAYBURRY, in the Chair.

Eighteen members present.

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* I have also been interested to see amongst the Illinois State Collections from the shale associated with the coal-bed at Danville, in that State, a new type of bivalves I had never before seen from any other locality than Nebraska City, Nebraska, where it occurs in the Upper Coal-measure beds referred by Prof. Marcou to the horizon of the Permian. It is a small, smooth, compressed, elongated, equivalve bivalve, with nearly parallel, straight upper and lower margins, and a distinct, rather large rectangular notch in the anterior ventral margin, forming a hiatus similar to that seen in the genus *Xylophaga*, though it evidently has no relations to that group, but seems to be allied to the *Solenidæ*. In Dr. Hayden's report on the Geology of Nebraska, I have proposed for this genus the name *Prothyris*.

From the same bed at Danville, Ill., I have likewise seen in the State Collection, specimens of Prof. Geinitz's Nebraska species *Gervillia longa*, one of which shows the hinge to have none of the characters of *Gervillia* or *Bakevellia*, since it has no trace of the row of cartilage pits characterizing those genera. On the contrary, it seems to agree well in its hinge characters with the genus *Avicula*.

F. B. MEEK.